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FOR THE

PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

ITEMS AND NOVELTIES.

The Westinghouse Air-Brake in England.—Two important trials of the Westinghouse Air-brake have recently taken place in England; one on the 10th of April on the Midland Railway, and the other on April 29th, on the London, Chatham and Dover Railway. The former of these trials was for several reasons the more important of the two, it "having been organized, not by those interested directly in the brake itself, but by the Directors of the Midland Railway Company, the object being to arrive at some definite conclusions, independent of the inventor's, as to the actual practical efficiency of the brake, under ordinary and extraordinary circumstances." Twelve of the largest railway companies of England and France were represented, the experiments being conducted under the direction of a Committee chosen from among them. The results of these experiments, as well as the conditions under which they were performed, are given in the following official record as published in the *Times* and subsequently in the *London Engineer*.*

* The train consisted of engine, tender, two vans, and twelve passenger coaches, the total weight, including passengers, being 184 tons, as follows:—Engine, 33 tons; tender, 22 tons; vans, 16 tons; coaches, 108 tons; passengers estimated at 5 tons. The tender and guard's vans had the air brake mechanism connected to the ordinary hand-slide brakes fitted with wood blocks. The coaches had cast-iron blocks; but the brake rigging on these was of three

Trials of the Westinghouse Continuous Air Brake on Midland Railway, between London (St. Pancras) and Bedford, on Friday, April 10th, 1874.

No.	Nature or kind of stop, &c.	State of rails.	Speed in miles per hour.	Gradient.	Time of stop from application of brake to absolute rest.	Distance run from application of brake to absolute rest.
					Seconds	Yards.
1	Ordinary station stop with air brake applied by driver, steam being first shut off	Dry	45	Up 1 in 160 and 320	18	253
2	Ordinary station stop with air brake applied by driver, steam being first shut off	"	36	Up 1 in 400	15	273
3	Steam shut off, air brake applied and engine reversed, but no steam applied. (The air brake practically stopped the train before the engine was reversed.)	Slight rain.	43	Down 1 in 200	20	320
4	Steam shut off, air brake applied, engine reversed, and steam applied in back gear. (Same as 3.)	Dry	43	"	22	336
5	Hand brakes applied on tender and guard's vans by signal of whistle from engine, steam being shut off	"	45	Up 1 in 173	65	880
6	Hand brakes applied on tender and guard's vans by signal of whistle from engine, steam being shut off and engine reversed, but no steam applied. (6 and 7 had ample time to obtain benefit of reversing.)	"	36	"	40	440
7	Hand brakes applied on tender and guard's vans by signal of whistle from engine, steam being shut off and engine reversed, and steam applied in back gear	"	45	Up 1 in 176	53	660
8	Air brake applied by guard in rear van, the driver on feeling brake shut off steam and applied the air brake from engine	"	56	Up 1 in 300	22	416
9	Air brake applied by guard in front van, the driver on feeling brake shut off steam and applied the air brake from engine	"	43	Down 1 in 660	21	330
10	Carriages were slipped, the air brake couplings broken away, and the portion left behind stopped by the application of the air brake from the rear van. (Eleven coaches and one van slipped.)	"	56	Down 1 in 200	27½	Not taken
11	Air brake applied from engine, and engine left in full forward gear with steam on. (Steam reduced from 120 lb. to 110 lb. during stop; mean air pressure, 70 lb.)	"	50	"	25	428
12	Steam shut off and air brake applied as if slacked by signals, brakes released and steam re-applied. (The vibration due to the brakes was scarcely appreciable. Some of the carriages rode a little hard, but that was due to the blocks being new.)					
13	Steam shut off and air brake applied; train brought to a stand; brakes released and train moved backwards; brakes again applied, train brought to a stand; brakes released, steam re-applied, and train again moved forward, showing the action of brake as regards quickness of release, &c.	"	50	Down 1 in 660	22	350
14	Driver stopped upon receiving signal from carriage No. 203 (third coach from engine)	"	32	Down 1 in 531	19	Not taken.
15	Driver stopped upon receiving signal from rear van	"	23	Down 1 in 200	17	"
16	Driver stopped upon receiving signal from front van	"	43	"	19	350
17	Air brake stop by driver at fixed point, as for water. (Came to stop opposite box satisfactorily from fifty-three miles an hour.)	"				
18	*Observations from Bank.*—Train being run past with brake on, so as to show the action of the brake with reference to skidding of wheels, or otherwise. Some of the trailing wheels were skidded just before the train came to rest					
19	Time taken to uncouple and couple two carriages with and without air brake. (Extra time taken to couple or uncouple brake pipes, 7 seconds.)					
20	Time taken by pump to restore pressure in reservoir after brake has been used. (To pump from 50 lb. to 80 lb. mean, 45 seconds; from atmospheric pressure to 50 lb., 57 seconds; to 60 lb., 71 seconds; to 70 lb., 87 seconds; to 80 lb., 107 seconds.)					
21	Stop with air brake with several of the couplings between the carriages disconnected. (Four couplings were disconnected on one side.)	Dry	45	Up 1 in 200	26	325
22	Stop with air brake after hole has been cut in one of the flexible tubes.	Wet	38	Down 1 in 371	29	about 350

With reference to this trial, the *Engineer* says:

"We cannot call to mind any recent occasion when a question connected with the working of railways was raised, on which so many eminent railway authorities were present. The list of names shows how great is the interest taken in the brake by railway companies, and proves that the experiments were all conducted under the observation of most competent authorities." "It will be seen that the experiments tried, were the result of a consummate knowledge of the conditions which a continuous brake should fulfil, and we venture to think that no railway brake was ever so fully tested before, or ever came so satisfactorily through an ordeal of exceptional severity."

Engineering, in an able editorial on the Midland Railway trial, while admitting that "the apparatus worked with the utmost certainty and afforded every satisfaction so far as giving proof of perfect efficiency is concerned," regrets that the experiments fell so far short of accuracy, and failed to give the data for such exact deductions as the science of engineering demands, and says "the Westinghouse brake, admirable though its performance was, is, we have no hesitation in asserting, capable of far better things as regards promptness in stopping the train." "If speeds, times, and spaces," it goes on to say, "had been registered with the mathematical accuracy attainable by suitable mechanical contrivances, it would have been possible to have determined, not the result simply, but also how that result has been obtained." Even from the data secured, important conclusions may be drawn. The true measure of the efficiency of a brake being the mean retarding force exerted during the period of its application, this force may amount, the rails being in good order, to one-fifth or one-sixth of the insistent weight, or say 400 pounds per ton. The retarding force actually exerted in the recorded experiments is deduced separately from the times and the spaces upon the record, by means of the formulas:

$$r = \frac{28\ v^2}{s} \text{ and } r_1 = \frac{115\ v}{t}$$

kinds:—First, with the two length equalizing rock shaft hanging levers, and one block on each wheel; second, with tension bars without rock shaft, one block on each wheel; and third, with tension bars and blocks on both sides of each wheel. The tender and guard's brakes could be worked by hand lever in the usual way, independent of the air brake. The air brake fittings were so applied on the carriages that the brake blocks could be caused to act at the will of the driver, or either of the guards, on every wheel of the train, the engine wheels excepted. Apparatus for signalling between passengers and guards and driver was applied. The brake pipes between the carriages served for the signalling line of communication. The experiments commenced upon the train reaching Hendon station.

r being pounds per ton exerted by the brakes, frictional resistances, gradients, etc., in stopping a train going at the velocity v in miles per hour, in t seconds, or within s yards. Thus analyzed, the experiments yield the following results:*

Number of Exp't.	Deduced from Space. Pounds per Ton.	Deduced from Time. Pounds per Ton.
1	176	252
2	128	236
3	173	258
4	168?	236?
5	52	67
6	70	91
7	73?	84?
8	203	286
9	160	239
10	not taken	246
11	174+?	241+?
13	203	265
14	not taken	198
21	164	188

The most obvious fact here brought to view is, that "in every instance the mean retarding force per unit of space is smaller than it is when referred to units of time." Errors of observation can account for only a part of the difference.

"A little reflection will satisfy us that the identity in the results ordinarily deduced, whether time or space be the element given, arises simply from the fact that we are usually dealing with some force of uniform intensity, such as the force of gravity. Having advanced so far, we see at once that the difference in our results, after discounting errors of observation, indicates a lack of uniformity in the retarding force; and from the direction of the difference, we see that the latter must be comparatively small for some time after the application of the brakes, and increase in intensity as the velocity of the train diminishes. Referring to the first experiment, where the mean retarding force per unit of distance is 176 pounds per ton, it will be obvious that this condition would be satisfied if the retarding force increased uniformly yard by yard from the mere frictional resistances, or say 35 pounds per ton at the moment of the

* In experiments 5, 6 and 7, hand-brakes alone were used, taking effect upon from 20 to 25 per cent. of the entire weight of the train; in 10, the engine was detached, and all wheels braked; in all other experiments about 80 per cent. of the entire weight was controlled by the brakes. In 4 and 7, the engine was reversed; in 11, the steam was kept full on.

application of the brakes, until at the end of the space traversed it touched 317 pounds per ton. But though the space traversed is unaffected by the distribution of the retarding force, provided the mean value be unaltered, it is otherwise with the time. If the 176 pounds per ton had been uniform in intensity, yard by yard, we should have deduced 176 pounds, also, in lieu of 252 pounds, as the mean retarding force per second. The effect of the retarding force varying from 35 pounds to 317 pounds may be shown to be such that the mean retarding force per second will be about one third greater than the mean retarding force per yard; hence, upon the above hypothesis, it would follow that in our first experiment the former would be about 235 pounds, the latter being 176 pounds. There can be no doubt, therefore, that this increased value of the retarding force per second, as compared with the resistance per yard, indicates a want of promptness either in the handling or in the action of the brakes.

"The mean retarding force per yard in the instance of the nine air-brake experiments given in the table, will be found to average 172 pounds per ton. How much of this is due to frictional resistances, and how much to the brake, it is impossible to say; for it did not occur to any of the experimentalists to ascertain the proper time and distance of the train itself, when neither air-brakes nor hand-brakes were applied. Some years ago Mr. Bramwell found that the distance of 1800 yards was traversed by a train almost identical in composition and weight with the Midland train, in running freely from a speed of 40 miles an hour until it came to rest. By the first equation, the corresponding mean retarding force will be found to be 25 pounds per ton. If we adopt this value for the frictional resistances of the Midland train, and deduct it from the gross retarding force of 172 pounds, we obtain 147 pounds as the average retarding force exerted by the brakes per ton of train. Since the brakes acted upon 80 per cent. of the entire weight of train, this will be equivalent to 184 pounds per ton of the load on the braked wheels; and since, in order to reconcile the observed times and spaces, we must assume that the retarding force of the brakes increased gradually from *nil* up to double its average intensity, we are led to the conclusion that it must have been equal to about 370 pounds per ton toward the end of the run. Now, with the rails in good condition, as they were on Friday last, 370 pounds per ton is just the pressure that would make it impossible for any one to predict whether the braked wheels would revolve or skid. It is no matter for surprise, therefore, that the wheels themselves exhibited equal indecision—some revolved and some skidded."

The article then goes to consider a question much mooted among us, *i. e.*, the question of the inconvenience to passengers from too sudden a stop. It asserts that the effects of sudden stops are too much exaggerated, and, in proof of this, it states that if the feet be placed against the seat in front, the face to the engine, the train going at thirty miles an hour may be stopped in ten yards without throwing a greater pressure on our feet than they sustain in walking. Indeed as we may safely trust our knees and boots under a load double that

of the body, the train might be stopped in three or four yards without serious inconvenience. The question of bringing the train to rest in ten rather than twenty seconds, therefore, is a perfectly immaterial one so far as concerns the passengers' comfort, while it may be a vital one when their safety is involved. The article concludes as follows: "It is a theoretical possibility to pull up a train in half the distance averaged in the midland trials, and we have no hesitation in asserting that the Westinghouse brake is capable of doing anything that is theoretically attainable."

American Bessemer Works.—We are indebted to Mr. Alex. L. Holley for the following interesting facts concerning the present condition of the Bessemer steel industry in the United States. Since no one can speak upon this subject with more authority than he, we are glad to be able to put upon record in these pages these most gratifying facts, so far as this branch of metallurgic art is concerned. To this great success Mr. Holley has himself in no small measure contributed.

PRODUCT OF AMERICAN BESSEMER WORKS.

This has been steadily increasing, from various causes—better organization, better refractory materials, and chiefly numerous large and small improvements in mechanical details. In 1868 an output of 500 tons of ingots per month was barely reached in the best works; in 1870, the production at Troy and Harrisburg had risen to about 1700 tons per month, maximum. Early in 1872 the Harrisburg works turned out above 2000 tons per month, and for a year or more these and the Cambria works took the lead in this direction, the latter plant having run as high as 640 tons in one week. During 1873 the Cambria, Harrisburg, North Chicago and Joliet works averaged twenty-five to thirty heats of five tons each per twenty-four hours. During the week ending July 12, 1873, the Harrisburg works made 180 heats yielding 890 tons of ingots. The product of the Cambria works, the week ending Jan. 17, 1874, was 189 heats, giving 956 tons of ingots. During one twenty-four hours (Friday, Jan. 16,) forty-six blows were made. On Friday, February 13, 1874, the Troy works made fifty heats in twenty-four hours, yielding 267 tons of ingots. This is the most remarkable run on record. During the week ending April 4, the Troy works made 195 heats, yielding 972 tons of ingots, which is the largest week's work. In January, 1874, the Troy works made 2899 tons of ingots, and in April the North Chicago works made 3526 tons, which is the largest month's work.

These are all five-ton plants, consisting of two five-ton vessels, and accessories, and they work only eleven turns, or five and a half days per week.

The blooming trains employed at Troy, Cambria, North Chicago, Joliet and Bethlehem, are capable of rolling more than the average product of the Bessemer works. The first of these was erected at Troy in 1870; the feeding tables were first applied by Mr. Fritz to the Cambria mill, and have since been applied to all the mills, with some modifications. The Troy and Bethlehem mills roll ingots fourteen inches square, weighing over a ton, to make three rails each. The other mills at present roll twelve inch two-rail ingots.

The production of rails from blooms has been more uniform because the rail train was a highly perfected machine long before the Bessemer process was introduced. The Cambria mill has often produced over 1000 tons of rails per week, from a twenty-one inch train. Probably the best week's running on record, all things considered, was the Troy, ending April 25, 1874, viz., 1012 tons of sixty-two pound rails, in eleven turns, from nine furnaces and a twenty-one inch mill; of these there *was not one second quality rail*, and there were but 3½ per cent of short rails.

The Geological Survey of the State of Pennsylvania.—It is with great satisfaction that we record the fact that a new geological survey of the State of Pennsylvania has been ordered. The bill providing for it passed the Legislature on the 14th of May, and the same day received the signature of the Governor. After ordering the survey, the bill makes an appropriation of $35,000 per annum for three years, to carry it into effect. The entire control of the survey is placed in the hands of a board of ten commissioners, together with the Governor, who is the *ex officio* president. This board is to have the appointing of the geologist-in-chief, is to fix the salaries of all the appointees, and to have the disbursing of all moneys. The geologist, when appointed, is to have the appointing of his assistants. He is to submit to the board a plan for the survey; if approved by them, it is to be carried out under his direction, and he is to be responsible for its execution. The board, as appointed by Gov. Hartranft, is composed as follows: Ario Pardee, Hazleton; Wm. A. Ingham, Philadelphia; Henry S. Eckert, Reading; Henry McCormick, Harrisburg; James Macfarlane, Towanda; John B. Pearce, Philadelphia; Robt. B. Nitson, Clearfield; Daniel J. Morell, Johnstown; Henry W. Oli-

ver, Pittsburg; S. Q. Brown, Venango county. We quote, with our cordial endorsement, the following remarks of U. S. Mining Commissioner Raymond, in the *Engineering and Mining Journal* of May 23d: "The names of these gentlemen afford a satisfactory guarantee that the duty entrusted to them will be conscientiously and intelligently performed. So far as the selection of a State geologist is concerned, their task will be easy. Professor J. P. Lesley is so generally acknowledged to be the right man for the place, that his appointment will be but the formal recognition and record of an overwhelming public sentiment in his favor. We congratulate the citizens of Pennsylvania that this great work has been taken up at a time when a great scientific worker, specially qualified for it and interested in it, is at hand to direct its execution."

Investigation of Prof. Thurston's Methods of Testing.—We are gratified to be able to note that the Government has taken notice of the admirable testing apparatus of Professor Thurston, and has appointed a Commission to investigate it and its results. We take the following statement of it from the "New York *Tribune*," of May 4th:

The Secretary of the Navy has recently directed a Board, consisting of representatives of the Naval Academy and of the several Bureaus of the Navy Department, to examine the method of determining the useful qualities of iron, steel, bronze and other materials of construction recently devised by Prof. R. H. Thurston, of the Stevens Institute of Technology, and to report upon the Autographic Recording Apparatus made at the Institute. This Board, consisting of Chief Engineer Danby, Naval Constructor Hanscomb, Commander Meade, Prof. Greene, Lieutenant-Commander White, and other officers, visited the Stevens Institute at Hoboken on Saturday, and spent several hours inspecting the apparatus, discussing the new method, examining new designs, and making experiments. They also made a short tour of inspection through the buildings of the Institute, and in the afternoon returned to the Brooklyn Navy Yard in a steamer.

On the Devitrification of Glass.—Some curious specimens of crystallized glass were lately sent to M. Peligot by M. Vicleau, director of a glass manufactory at Blanzy, which were taken from a furnace which had been for some time out of use. These crystals differed completely, both in aspect and in mode of formation, from all the specimens of devitrified glass heretofore examined by M. Peligot. They were well developed prisms, twenty to thirty millimetres in length, and recalled in appearance crystals of sulphur and of bismuth

crystallized from fusion. Their analysis threw some light upon the obscure question of devitrification. While certain chemists maintain that this result is nothing but the separation in crystals of a definite silicate in the midst of the vitreous mass—a true segregation—others affirm that devitrification is a simple molecular change, in which the entire mass of the glass crystallizes, a phenomenon analogous to the change by which arsenous oxide becomes opaque. Peligot's analysis of these Blanzy crystals supported the former hypothesis, by showing that the crystallized portions differed in composition from the original glass. They contained no sodium, but had an excess of magnesium, corresponding to the pyroxene group. The crystals were altered by exposure to the air. They fused at a much higher temperature than the normal glass out of which they came. M. Peligot called the attention of the Academy to the large amount of magnesium present, suggesting its agency in the transformation.

Remarkable Motive Power.—A curious capillary experiment was devised by M. Lippmann some months since, which the author has recently utilized in a very ingenious way. The original experiment is thus described: Place in a saucer or in a large watch-glass a globule of mercury an inch or two in diameter, and pour upon it a little water acidulated with sulphuric acid and slightly colored with potassium bichromate. If now the mercury be touched laterally with the point of a needle, the globule will be observed to contract and withdraw itself from the needle, then to extend again to its primitive position. This brings it again into contact with the needle, the contraction is renewed, and so on indefinitely. When the globule is quite large it executes contorted and grotesque movements which are surprising to those who are not in the secret. The explanation of this phenomenon is found in the fact that under the joint influence of the iron and the bichromate, the mercury is successively oxidized and deoxidized, thereby producing an alteration in its capillary condition and causing the swelling and flattening. This oxidation and deoxidation may also be effected by an electric current. The globule is seen to swell up or to flatten, according as it is connected with the negative and deoxidizing or with the positive and oxidizing electrode. It is this oscillating motion of the globule of mercury that M. Lippmann has utilized in his motor. It is constructed as follows: In a trough of glass two small cups are placed, full of mercury; in each of these moves a piston formed of a bundle of glass tubes. The trough is filled with acidulated

water, and the two masses of mercury are in communication with the electrodes of a battery in such a way that when the one contracts the other flattens. Consequently. when one of the pistons rises the other falls: and by simply transforming this reciprocating motion of the pistons into a rotary one, an electro-capillary engine of some hundredths of a kilogram-metre of power is readily obtained. In the machine actually constructed by M. Lippmann the fly-wheel made a hundred revolutions per minute.

The extremely feeble current needed to set this engine in action suggests its use as an indicator of currents too feeble to be detected by the ordinary instruments. Used in this way it would constitute an extremely sensive electrometer. Indeed it might come in use for the reception of cable dispatches, which, as is well known, are sent by means of very feeble currents. Certain movements of the machine might correspond to certain predetermined characters or sentences, and in this way the dispatch might be easily deciphered. Though scarcely more than curious at present, these experiments of M. Lippmann are excedingly interesting, and will undoubtedly in the future receive important applications.

Use of Fluor-Spar in Working Puddling Cinder.—According to the second of the laws of chemical reaction enunciated by Berthollet, when fluor-spar and coal are heated with a silicate of iron, carbonic oxide and silicon fluoride are produced, and pass off as gaseous products, while the iron is left behind entirely desilicified. In 1872, M. Maussier, a French engineer, took out a patent for applying this reaction to the treatment of slags rich in iron, particularly those from the puddling furnace. Enormous quantities of these slags fail of utilization because, although they contain sometimes as much as fifty per cent. of iron, yet, on account of their easy fusibility and the difficulty of their reduction, but a small proportion can be worked in the charge of the ordinary high furnace. Nor have the attempts hitherto made to work them specially been more successful. By the use of fluor-spar, however, according to the reaction above given, it is possible to obtain in the ordinary puddling furnace, the cast-iron hearth being covered with scrap iron and kept from fusion by artificial cooling, a true brown hematite by the oxidation of the desilicified iron. By adding hammer-scale to the bath, a true iron ore of determinate composition may be produced. If, in place of the oxidizing flame, the reducing flame of the Siemens or Ponsard furnace be em-

ployed, the iron produced upon the hearth may be cemented directly, so as to produce even a cast-iron. This may then be puddled directly, either alone or with the addition of a charge of spiegel, and, if desirable, in the mechanical puddler of Danks or Pernot. But, in whatever way treated or worked, the process yields metallic iron.

In the high furnace, the use of fluor-spar in the charge renders it possible to introduce very much larger quantities of puddling cinder successfully.

Limit of Elasticity in Glass.—In a series of researches upon the compressibility of gases, M. Cailletet has been led to study the resistance which glass tubes oppose to rupture. By an ingenious method he has determined exactly the amount by which the volume of a hollow cylinder of glass varies, either when compressed within or upon its exterior. In one experiment a tube of 55 cm. (21·7 in.) long and 17 mm. (0·7 in.) in diameter, was crushed by an outside pressure of 77 atmospheres. One-half this pressure sufficed to break it when exerted upon the interior. When the glass is very thick, so as to resist pressure of 400 or 500 atmospheres, it suffers no permanent set. Upon this fact, M. Cailletet has constructed a manometer, at once simple, delicate and precise.

Franklin Institute.

HALL OF THE INSTITUTE, May 20th, 1874.

The meeting was called to order at the usual hour, with Vice-President Bloomfield H. Moore in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at their stated meeting held May 13th, donations to the Library had been received as follows:

Proceedings of the American Philosophical Society, Vol. 13, June to December, 1873. From the Society.

Proceedings of the Literary and Philosophical Society of Liverpool during the Sixty-second Session, 1872–73. From the Society.

Proceedings of the Scientific Meetings of the Zoological Society of London for the year 1873—Part 1, January to March, and Part 2, March to June. From the Society.

Annales de Chimie et de Physique, December, 1873, Vol. 30, and January, 1874, Vol. 1. Paris. From the Editor.

Bulletin de la Société d'Encouragement pour l'Industrie nationale, for December, 1873, and January, 1874. Paris. From the Society.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Index for Vol. 76 and Vol 77, Nos. 21 to 26. Paris, 1873. From the Academy.

Transactions of the American Philosophical Society, Vol. 15, Part 1, 1873. Philadelphia. From the Society.

Das Gebirge um Hallstadt. Eine Geologisch-Palæontologische Studie aus den Alpen, Part 1. Von Edmund M. v. Majsvar. Vienna, 1873. From the K. K. Geologischen Reichsanstalt.

Verhandlungen d. K. K. Geologischen Reichsanstalt, Berichte vom 31st July, and October, 1873. Vienna, 1873. From the K. K. Geologischen Reichsanstalt.

Jahrbuch d. K. K. Geologischen Reichsanstalt, Vol. 33, July—December, 1873. From the same.

Zeitschrift des Architekten und Ingenieur Vereins zu Hannover, Vol. 19, Part 3. Hannover, 1873. From the Society.

Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains; being the Fifth Annual Report of Rossiter W. Raymond, U. S. Mining Commissioner. Washington, 1873. From the Author.

Treatise on the Method of Government Surveying as Prescribed by the U. S. Congress, &c. By Shobal & Clevenger, U. S. D. S. Washington, 1874. From S. V. Clevenger.

Report of the Proceedings of the Meteorological Congress at Vienna. Protocols and Appendices. Translated from the Official Report. London, 1873. From the Meteorological Committee of Royal Society.

Fourth Annual Report of the Board of Commissioners of Public Charities of the State of Pennsylvania. Harrisburg, 1874. From the Board of Public Charities.

Annales des Mines, Vol. 4, Part 6, 1874. Paris. From the Editor.

Monthly Report of the Chief Engineer of the Manchester Steam Users' Association, December, 1873; also, the Annual Report of the Committee of Management to the Members of the Association Manchester, 1873. From the Association.

Proceedings of the Royal Geographical Society of London, Vol. 18, No. 2, 1873. From the Society.

Proceedings of the Royal Society, Vol. 21, Nos. 146, 147; Vol. 22, Nos. 148 to 150. London. From the Society.

Journal of the Society of Arts, Vol. 22, Nos. 1111—1114. London. From the Society.

Die Fauna der Schichten mit Aspidoceras Acanthicum. Von Dr. M. Neumayer. Vienna, 1873. From the K. K. Geologischen Reichsanstalt.

Sundry English Patent Specifications for the Years 1872, 1873, with Abridgements. London. From the Hon. Commissioners of Patents.

The Actuary likewise reported the following recommendation from the Board:

Resolved, That, at the next meeting of the Institute, the following be offered as an amendment to the By-Laws, Article 2, Section 7: Members whose yearly dues are in arrears for three years shall be considered as having resigned, and the Actuary is directed to strike their names from the list of members.

The proposed amendment was laid over for consideration for one month.

The Actuary then reported the minutes of the several standing committees.

The special committee appointed by the President to draft a minute expressive of the sense of the Institute upon the death of Joseph Harrison, Jr., then presented the following report:

Your Committee to whom was referred the preparation of a minute commemorative of the life of active usefulness of our late fellow member, Joseph Harrison, Jr., report that he was born in the city of Philadelphia September 20, 1810. At the age of fifteen he was regularly apprenticed to learn the trade of machinist, and under two masters (the first having failed) he terminated his indentures with credit, and entered upon his duties as a journeyman machinist with a reputation for industry and ability as a workman. In 1837 he was taken into the firm of Garret Eastwick & Co., and in 1843, in connection with his partner, Mr. Eastwick, and Mr. Winans of Baltimore, he made a contract with the Russian Government to build engines in Russia with Russian workmen. The contract was for five years and amounted to the sum of three millions of dollars. In a strange land and knowing nothing of the language, surrounded by people ready to take advantage of any weakness, under a government proverbial at that time for the corruption of its under officials, the work was begun and so well done as to lead to other and more important contracts, and to cause the American firm to be respected by the people of all lands with whom they had dealings.

In 1852 he returned with his family to his native city to expend his ample fortune in beautifying his home. Many and beautiful are the monuments of his taste in architecture, and in all are seen the peculiarities of his mind trained in the mechanic arts. About him he gathered treasures of art, and proud was he of the production of the pencil and chisel of native artists. In his love

of the fine arts is shown the refined cultivation needed for success as an artisan. Mr. Harrison was an earnest advocate of the city owning galleries of painting and sculpture, to be at all times open to all who would study the beauties of art. He would have had our working people familiar with high art, and for this end he would have had that art as free to them as is the air we breathe.

At home he conceived the idea of improvements in the construction of steam boilers that have made his name famous. Your committee deem it a work of supererogation to repeat in these halls what Mr. Harrison has done in this direction. Others may have enunciated the principles that he carried into practice; to him and to him alone is due the credit of establishing, as a manufacturing interest, steam generators in the strength of the smallest part, or unit of which lies the strength of the structure as a whole. Following in his footsteps, others will surely reap a rich reward from what he has begun, and even if his invention, as conceived by him, should pass out of use, the fundamental principle will remain as the foundation for others to build on. One at least of those to whom you have assigned the task of commemoration knew him during all the years he labored to perfect his invention, and knew him as an earnest mechanic, as a lover of the mechanic art, as a kind and loving father and a sincere christian gentleman—knew him in his strength, when he longed to benefit his fellow-men. Suddenly a painful malady beset him, and for five years only those who were with him much realized how great a sufferer he was and with what patience he bore the pangs of his dreadful affliction. On March 27th, 1874, death ended his suffering. Few men beginning life so humbly have risen to higher honors in the ordinary walks of life.

His connection with this Institute began in 1834, when he was elected a member, and for three years he sat in the Board of Management. The *Journal of the Franklin Institute* contains among its volumes several valuable contributions from his pen. As in the case of others of our members who have passed away, we recognize in his mind that growth with his years and opportunities that rewards all seekers after knowledge. When it is known that he had never been required to write a composition at school, had never written a letter until he was a man grown, the ability of each one to educate himself becomes manifest in his progress in knowledge.

From his life history we may draw the best of lessons as to what can be gained by steady industry and due application to all that is needed to insure mental growth.

Your Committee, in conclusion, offer the following:

Resolved, The Franklin Institute tenders its earnest sympathy to the family of the late Mr. Joseph Harrison, Jr., in their affliction, and in conveying to them the record of this minute they wish to express the high esteem in which they will ever hold his memory.

All of which is respectfully submitted,

COLEMAN SELLERS,
HECTOR ORR,
GEORGE F. BARKER,
} Committee.

The report as read was received, and the resolution therein contained was adopted.

In this connection Mr. J. B. Knight, on behalf of Mr. Alexander Purves, presented the following communication:

The resolution adopted by the Franklin Institute at its last meeting, to make proper mention of the life and death of our late member, Joseph Harrison, Jr., brings to my mind a circumstance that occurred between him and myself, of which I give the substance. It will show Mr. Harrison's sentiments and the drift of his mind when he was a young man.

Many years ago, when Mr. Harrison was closing out his business preparatory to going to Russia, I bought from him a lot of machinery and metals. The bill came to more than we expected and more than I had money to pay with. I asked him to trust me for a part of the bill, promising to pay in a short time; he hesitated, and saying that I was a stranger, perhaps would not pay, but sell myself for the balance due. After some conversation about my just beginning business and the small amount of my capital, he consented. I paid him promptly at the time agreed upon. Mr. Harrison was much pleased, and said he "did not intend to hurt my feelings in what he had said the other day about selling, but he *did mean* that thousands of beginners and others failed of success in business through the want of promptness and faithful discharge of their engagements. The neglect to pay an amount promptly, however small, makes a doubt. If not paid at all, the party sells himself for a trifle and never will succeed. To be truly successful in business or in any sphere of life one must have the faith and confidence of his fellow-men, which is far more valuable than his capital and can only be had by prompt and faithful performance and strict integrity in all engagements, without which neither man nor nation can prosper permanently."

Our conversation, I might say his lecture, was quite extended. Among the most important matters, he held that "man must be true to himself; he must not make engagements without reasonable prospects that he can fulfill them, nor must he be too timid, for then he will accomplish nothing, but should use that reasonable judgment which becomes a man." Mr. Harrison was plain spoken; he regarded fraud in any form, such as short weight, overreaching or deception in an agreement, or bribery, to be, in plain English, stealing, which, although not known to others, is known to one's-self, and hangs like a dead weight upon the soul, dragging him down from that self reliance and confidence of manhood which alone gives him fortitude to meet as a man all the affairs of life. Under ordinary circumstances there is plenty of room and means in the world for a man to earn his own bread without stealing that which belongs to others, if he will but use his mind and energies. In our country he must be a miserable being (or a most unfortunate one) who cannot by his own determination thrive and lay by something for the future; *failure* is generally our own fault. Mr. Harrison said he was going to Russia among strangers. He felt confident of success, although he had but little more money to operate with than I had, but *success or failure*, he would come back without degrading himself by fraud in any way. If he did not succeed as he expected, he would return to the anvil and the lathe at home.

My own experience in life would verify the sentiments of Mr. Harrison—that strict integrity in all things is the only way to success, usefulness, honor, man-

hood and a conscious happy life. I wish that young men could be deeply impressed with Mr. Harrison's noble sentiments; they are universal, not that Mr. Harrison's life can be imitated, for that cannot be—it was his—but they can build their own life by the same *great virtues of manhood* and make a success or failure by their own doings. *No one knows* what he may be called upon to do in the shop, in the building of structures, or even in the affairs of state. In every place *we can make an effort*. Without manly virtues we will certainly fail. Mr. Harrison's was an extraordinary success. An apprentice boy, without money or friends, in a far-away country, among strangers, he inspired confidence and faith, which enabled him to do mechanical works and build structures which are an honor to any one. He lived a most respected, useful and honored life, and died in the possession of millions.

A. PURVES.

The Chairman next introduced Mr. Calvin Pepper, of New York, who read a paper on the subject of Silicon-Iron and Steel, in the course of which the speaker elucidated his process of manufacturing these materials, and gave an account of their properties. In conclusion, he announced that the subject was at present before the Committee on Science and Arts, for examination and report.

Mr. Horace McMurtrie, of Boston, next followed with a paper on Steam Boiler Explosions no Mystery, a carefully prepared essay, in which the author claimed, from the evidence of statistics, that the explosion of steam boilers was in every case assignable to a simple and preventable cause. The paper was discussed by Messrs. Wiegand, Lovegrove, Le Van and the author.

Mr. Wm. B. Le Van followed with a paper descriptive of a late steam boiler explosion which occurred in this city.

The Secretary then presented his Monthly Report on Science and the Mechanic Arts, in the course of which specimens of cloth and paper manufactured of asbestos, in Glasgow, Scotland, were exhibited.

Mr. Alex. Bary next described and illustrated, with the aid of the stereopticon, a design for the proposed Centennial Exhibition building, as submitted by A. B. Bary, G. R. Pohl and J. H. Cofrode, engineers and architects.

Six additional names of members to serve upon the Committee on Exhibitions, were offered by Mr. Hector Orr, and ordered to be added to the list.

The meeting was thereupon adjourned.

WILLIAM H. WAHL, *Secretary.*

Civil and Mechanical Engineering.

THE METRIC SYSTEM IN OUR WORK-SHOPS; WILL ITS VALUE IN PRACTICE BE AN EQUIVALENT FOR THE COST OF ITS INTRODUCTION?*

By Coleman Sellers.

In compliance with the invitation of the General Supervisory committee, as expressed through your Secretary, that, as an associate member of the American Railway Master Mechanics' Association, I should prepare a paper on some subject relating to the objects for which this association has been organized, I have decided to call your attention to a matter which may before many years be forced upon you, and which you should be prepared to consider with care; I allude to the proposed introduction, by legislative enactment, of the French system of measurement, known as the metric system.

It is not my intention to discuss the subject in all its bearings, for it is a theme requiring more pages of manuscript than I would care to inflict upon you. But I will state in as few words as possible how the proposed change would be likely to affect the workshops of the land. It is now about three-quarters of a century since the metre was first made the legal standard of length in France, and during that time it has been adopted by other countries, either in full or in part; so that the advocates of its universal adoption claim that the proportion of the population of the globe already enlisted in its use numbers 420,000,000. Hence they argue that, for the sake of a uniform metrological system all the world over, England and the United States of America should also adopt it to the exclusion of our present system of inches, feet, etc.

Many of our leading colleges are making the metric system the method of measurement in all their teaching, with a view to sending their graduates into the world as advocates of what to them seems so perfect a system.

There can be no doubt that it is very desirable to have uniformity, not only in regard to measurements of all kinds, but also in money, as such uniformity would certainly facilitate trade and advance our

* A paper read at the Chicago Meeting of the American Railway Master Mechanics' Association, May, 1874.

knowledge of the works of other countries. Those who use the metric system in all scientific matters find it wonderfully well adapted to facilitate calculation. In spite of its long names it is easily understood by persons of moderate education, and can be used even by those who have no idea of the Latin and Greek words from which the names are derived. If the world, as we know it in our arts and trades, was to be made over again, and we were obliged to adhere to ten as the base of our arithmetic, it would doubtless be a good thing in some respects, but very unhandy in more respects, as not admitting of binary division. I have heard it declared by men of high intelligence that its introduction now is retarded only by prejudice, by the unwillingness of people to give up what they are used to, and the necessity of learning certain new rules and methods of thought. Unfortunately, may be, there is something more than these objections that will retard its introduction. The change involves the expenditure of money—of very large sums of money. When this cost is presented to our minds, we may well consider whether the results to be obtained will warrant the expenditure.

The late Senator Sumner was its earnest advocate, and at one time was determined to push the adoption of the metric system. He said to one of our most distinguished scientists, "I am content to have it legalized in 1870 and to have its use then optional, but in 187– I would make its use compulsory." The gentleman to whom he addressed himself asked if he had well considered what a tax such a measure would impose on the country. "We have now in use," he said, "in all kinds of trades, the pound as our unit of weight, and Messrs. Fairbanks and other scale makers have for years been making platform scales with beams graduated to pounds. The edict that abolishes the pound will necessitate a change in all these machines for weighing. All their beams must be removed and regraduated to the new unit at an enormous expense." He instanced the change in the weight unit as the one most readily made, as it in the main affects perishable property only.

On February 8th, 1870, a resolution was passed in the United States Senate, that "The President be requested, if not incompatible with the public interests, to invite a correspondence with Great Britain and other foreign powers with a view to promote the adoption, by the legislatures of the several powers, of a common unit and standard of an international gold coinage," etc. In accordance with the spirit of this resolution, a dispatch was prepared by the Department of

State.* In this paper, after recounting the requirements of such a unification in coinage as shall not prejudicially affect our interests, it says:—

"It is to be observed that an identity in the measures of value in the different countries will not completely attain the beneficent results which are sought, unless there be also an identity in weights and measures. * * * * In commercial transactions an identity in measures of value would be of comparatively little use if unaccompanied by identity in the measures of the quantities to which those values are applied. There would still be a necessity for the intervention of an expert to shift the expressions of the measures of quantity, from the terms used in one country, to those in use in the other. The resolution of the Senate does not contemplate the extension of this correspondence to these points; nor in my judgment would it be desirable to do so.

"It would probably not be difficult to induce the people of different countries to adopt a common standard of weights and measures so far as perishable property is concerned. At first the adoption of unaccustomed systems might cause inconvenience and discontent, but if they should prove to be better than the old ones, and if they should have the further advantage of being common to several countries which possess a common standard of value, and which have extended commercial relations, it is probable that the inconvenience would be patiently submitted to, in view of the greater benefits to be derived from the change.

"But it seems to the Government of the United States that a forced change in the measures of distance, as applied to imperishable property and the permanent investment of capital, may be attended with more serious inconvenience. Thus while it may be practicable to establish a new standard of length-measure for articles of international commerce, such as textile fabrics which are consumed and do not remain, it may be more difficult to make the same change in the standard for permanent values. A few examples will demonstrate the difficulties that would probably attend a change in such measures in this country. * * * *

"It is the custom in the United States to lay out all towns and cities in regular quadrangles, and to divide each quadrangle into an even number of lots with an even number of feet. This has been found a convenient mode of dealing in town and city lots and in town and city houses. To make an arbitrary change, which should abolish these measures and substitute different ones in their places, involving the use of fractional numbers, would occasion great inconvenience, and might check the dealings in this species of property, and cause a loss to those who happened to be holders at the time of the change.

* See U. S. Report on Foreign Relations for 1870.

Again, the whole system of titles in those states which have been created out of the public domain rests upon government survey, whose results are expressed in the English mile and its subdivisions, rods, feet and inches. To substitute a different measurement would be a work of serious magnitude.

"Again," and this is what most seriously affects our interests, "the manufactories of the country are filled with machinery, whose delicately adjusted parts, measured in feet, inches and component parts of the inch, work together in one grand whole, which is in its turn combined in the same system of measures. To produce this machinery, thousands of shops are filled with costly plants, adjusted upon the same scale, whose delicate operations often require a nicer determination of measurement than can be obtained without mechanical aid. To transmute these measurements, so delicate and accurate, from the present system into a new one, would appear to be an almost endless labor, if indeed it be a possibility."

To show how clearly these statements express the difficulties that would attend our adoption of the metric system, I will call your attention to certain conditions of the mechanic arts in America, perhaps not fully appreciated by those who think the change is one of education only.

Eli Whitney, whose name has always been associated with the invention of the cotton gin, started, in 1798, an establishment for the manufacture of small arms on the principle known as the interchangable system, carried out by the use of hardened jigs or forms of the same shape as the parts to be produced, thereby making all parts of guns alike and interchangable one with another. He introduced the use of milling, by means of revolving cutters, those intricate shapes needed in gun work. When he proposed to Thomas Jefferson, then Secretary of State in Washington's Cabinet, to make an arm modelled after the approved French Charville flint-lock, in which all parts of all guns should be interchangable, he was ridiculed by both French and English ordnance officers. The government aided Mr. Whitney, and in 1800 the present Springfield Armory was established, and Mr. Whitney's inventions and system put in force there. It was not until 1855 that the English War Department was forced to adopt the same system, importing a large amount of machinery from America for that purpose.

This was not the only branch of the mechanic arts that was benefitted by this interchangeable system. America, contending with high labor, has been forced to exercise ingenuity, and make labor-saving machines produce cheaper work. This could only be done

by carrying the interchangeable system into other processes of manufacture; and American clocks, watches, sewing machines and all the countless small articles of hardware, are made by machinery. each piece like the others. Recognizing the absolute need of this interchangeable quality in everything manufactured, but few trades exist in this country that do not avail themselves of its advantages. Gradually, separate and distinct manufacturing establishments have come to use the same standards and to make their production interchange one part with another. Witness the various devices making up what is known as line shafting, as also all the screws and fittings for steam, gas and water pipes, and now the so complete recognition of the American system of screw threads for bolts and nuts. The primary object of this Association may almost be said to be to introduce uniformity in all parts of the great railroad system of the United States. There is no country in the world where the value of uniformity in the devices used in common by all mechanics, is so fully recognized as in this land of ours. What has been done in this direction, and what is being done now, is founded on the inch as the unit of measurement in the machine shop.

The machine shop, however, is not independent of other trades, and it is necessary to a proper understanding of our subject, that we have a clear perception of the nature of this inter-dependence. Machines made of metal have parts cast and parts forged. Wrought-iron is procurable in bars of certain merchantable sizes. When rolling mills are obliged to make round iron, differing in diameter from these merchant sizes, the price per pound is increased, as special appliances and extra care is required. So the mechanical engineer conforms his proportions to the procurable sizes of bar iron, and uses the iron, as far as possible, without the expense of re-forging into other sizes. This is noticeably the case in regard to rounds and squares. The tools and appliances in the machine shop have in time been made to conform to these sizes, and are all expressed by the division of the inch into halves, quarters, eighths and sixteenths. All the gearing in the country, all the patterns of cog wheels, are spaced in the teeth, by pitches, measured in inches, and the binary division of the inch, $\frac{1}{4}''$, $\frac{1}{2}''$, $1''$, $1\frac{1}{2}''$, etc., pitch; or, in number of teeth to the inch in diameter, called in practice per-inch wheels, as 12, 10, 8, or 6 per-inch, meaning so many teeth to each inch in diameter; as, for instance, a wheel three inches in diameter cut to ten per-inch, has thirty teeth, *i. e.*, $10 \times 3 = 30$. The patterns of gear wheels, in some instances,

form no insignificant part of the stock in trade of large machine shops, and the immense number of wheels now spaced to pitches in inches must necessitate the continued use of them, whether we call the pitch 1″ or 25·38 mm.

When the metric system was introduced into France, all machine work was done by hand; the planing machines for metals, and all the various appliances known as machine tools, with the exception of the turning lathe, were almost unknown. Sizes expressed in one measurement or another were of less moment than now. I dare say many of my hearers remember the time when the rule of thumb was the mechanic's rule; when the "boss" chalked out on the carpenter's bench a thing about "so big," to be made in metal, and then some other thing was made to fit it; at such time it mattered little what standard was used as measure. While French savants were laboring to build up this decimal system of interchangeable measures, the better class of American mechanics were solving the problem of making machinery with interchangeable parts. I am perfectly willing to concede that there are workshops in the land, in which the change from the inch to the metre could be made at very little cost, simply because these shops are furnished with no special devices for measurement even at this day; such drills and mandrils as they may have are altered in size at the whim and fancy of the workmen. The proprietor of one of this class of shops asked me, not many years ago, if we had a pattern of spur wheel of some pitch and diameter; and when I asked him if he had measured the diameter at pitch line of wheel, he wanted to know what the pitch line meant. Metres would do for that man quite as well as inches. Such machinists, in stating dimensions, use the terms full and scant to express fractions which might be quite readily stated with accuracy; sometimes, however, indulging in the extra expression of a "leetle full scant" for very nice measurement.

A well furnished establishment is provided with gauges, mandrils, reamers, standard drills and boring tools, as well as all other appliances needed for accurate work made to certain fixed sizes, and in most shops these special tools amount in value to large sums of money. The nomenclature of the sizes of these tools, as expressing the work they are expected to do, is part of their economical use; thus, an inch reamer is expected to make a hole exactly one inch in diameter, and no great effort of memory is needed to designate its size; but this same inch reamer will make a hole 25·38 millimetres in diameter—which is the same size expressed in French measurement.

In the machine shop the unit of measurement is the inch—it is not the foot nor the yard—we express in inches all measurements of objects that may sometimes be made less than one foot in size. Thus, pulleys are rated as 5″ or 10″ or 72″ in diameter. Boilers are spoken of as being 36″, 42″ or 48″ diameter. Car wheels are 30, 32 or 36 inches in diameter. For all calculations in the drawing rooms we use the inch and its decimal divisions, corresponding exactly with our dollars and its division into halves, quarters, eighths and sixteenths. As in money, we say half a dollar or fifty cents with equal facility, so in measurement we have the half inch or ·50 inch, each as expressive of size as the other.

The advocates of the substitution of the metric system for our favorite inch, say we have only to give new names to these sizes. This we can do; we can call our inch 25·38 millimetres, or, if we prefer, we can call it the twenty-five hundred and thirty-eight hundred-thousandths of a metre; or we can call it two centimetres, five millimetres and thirty-eight hundredths of a millimetre. They say, further, we can make a slight change in our sizes, and dropping the fractions of the millimetre use the even millimetre; thus our familiar inch would be replaced with the twenty-five millimetre size, which is a decidedly "scant" inch. As an appendix to this paper, I give a list of all our usual fractions of the inch, and our even inches up to twelve inches expressed in metric measurement.

Let me now explain how this change of size is to be brought about; that is, what we must do if we are obliged to give up our inch. The drawings of all our machines—drawings that have accumulated through many years, and are expressive of enormous sums of money and the best mechanical talent of the land—must be gone over and all the sizes changed. To express in millimetres the present sizes in inches would never do—it would involve us in a sea of fractions that would drive any ordinary brain crazy. No, we must alter all the sizes to the nearest even millimetres. Thus, some dimensions, marked three inches, must be changed to seventy-six millimetres, ·14 of a millimetre smaller than three inches, and some other size must be altered to make up the loss. Think of the labor involved in such a change, and you will not require me to say what such a change will cost. But it is said new work can be made to the new sizes, and the old sizes can be continued for the time. This is exactly the point I wish to reach in the statement of trouble and cost involved.

Drawings made twenty-five years ago are in use to-day, and draw-

ings made during each of the succeeding years are many of them in use, and the tools and gauges are perfected to manufacture machines in accordance with these drawings. To-day we begin new drawings with the new dimensions; the change can be readily made in the drawing room. It requires no vast amount of education to substitute one drawing scale for another. We send the new drawing into the machine shop and then the cost begins; all our old tools of fixed sizes, all our old gauges, are wrong; new ones must be made, and we must run the risk of mistakes from the simultaneous use of two standards. Now, for your information, I have taken the trouble to make a careful estimate of the cost involved in altering or making new (for we dare not alter all the taps, dies, reamers, mandrils, gauges and the other guides for the workmen in an establishment fully equipped for say two hundred and fifty machinists), and the sum foots up to $27,000 —more than one hundred dollars for each man employed. This does not contemplate any change in existing drawings; should we attempt to alter all the drawings, I cannot see how, in the same establishment, the change could be made at a cost less than one hundred and fifty thousand dollars. What do you think of such a change at such a cost? Would it not indeed paralyze this industry?

President Barnard, in his very able report in favor of the metric system, or rather in favor of some unification of measurement, says, "I do not expect that this system will make its way in the world against the will of the people of the world. I do not expect that our people, and I do not desire that any people, shall be coerced into receiving it by the force of 'imperial edicts' or by the terror of bayonets. What I do expect is that they will sooner or later welcome it as one of the greatest of social blessings. What I do expect is that they will one day become conscious of the many inconveniences to which they are subjected from the anomalous numerical relations which connect, or rather, we might say, disjoin, the several parts of their present absurd system; inconveniences which they have learned to endure without reflecting on their causes or suspecting that they are unnecessary in the nature of things; and that when fully at length awake to the slavery in which they live, they will burst the shackles and rejoice in the deliverance which the metric system brings. This cannot take place, of course, until the people are thoroughly informed."

Business men in all times look at the cost of each change. School men see beauties in the metric system and train their pupils as its

earnest advocates, but they do not count the cost. If it is needful to make the change it can be made more cheaply to day than to-morrow, more cheaply this year than next. While the schools educate the people to see its advantages, the money value of the permanent plant to be changed is increasing more rapidly than the uninformed on this subject can appreciate. Changes in such things as standards of measurement have been made in other countries, and changes, if needful, can be made now; but the question may in all fairness be asked, is it needful in this instance? So far as my own experience goes, having had the opportunity to use the inch and millimetre in one and the same establishment for many years, using one with as much familiarity as the other, my choice is most decidedly in favor of the inch as the unit of measurement in the machine shops and on the railroads of the country. That others think so too, in regard to one question in mechanics, let me prove by an example. Many years ago Mr. Whitworth attempted to establish a uniform system of screw threads based on the inch as its unit. His scheme met with such success that now, with the exception of France only, all the metre using peoples of the world have adopted the Whitworth system, and it has even been largely adopted in this country. It is considered better and more convenient than the French system. According to Mr. Whitworth's system, a half inch screw should have twelve threads to the inch; to express this in the metric language, a bolt 12.7 millimetres should be 2·12 millimetres pitch. I have said business men count the cost before making changes in matters of habit or use, but when they can be shown that they will be gainers by the change they give in to it heartily. This same example of screw threads will serve as an illustration. Mr. Whitworth's system of screw threads was already introduced in all the principal workshops of Europe and in many in this country. But a better system was presented to the Franklin Institute, a system based on such simple laws that, given the formula with no existing original to copy, any careful workman can originate a given thread that will match those in use. After an exhaustive debate on the subject of its introduction by the various departments of our government, and a careful consideration on the part of our mechanical associations, it came to be adopted as the United States standard. It was adopted at considerable expense because it was believed to be an improvement on existing practice. We have still to keep up our old taps and dies for repair work, but no mechanic has deemed the expenditure involved in the change other than judicious.

To enable you at your leisure to consider the value of our inch unit as compared with the French system, I have added to this paper (appendix B) a list of some of the prominent metric screw systems as compared with the United States standard and the Whitworth.

Recognizing the advantages offered by the decimal system in money, we accept the dollar and cents in preference to the pound sterling of England. We now have in use, in land surveying in the country, the chain and its decimal division. In city measurements the foot and its decimal division is also used, and in mechanics we have the inch as our unit, with its division into one-hundredths for calculation, and into vulgar fractions where its written expression is rendered plainer thereby. I have in this paper made no attempt to discuss the merits of the metric system as carried out in all its perfection, through measures of distance, surface, solidity and weight. This has been considered by abler men than I am. My object has been to present to you the cost involved in the change, and to show that something more than want of education strengthens the hands of Englishmen and Americans in resisting any change in their methods of measurement. By the law of our land, those of our citizens who choose to use the metric system can do so, and their so doing will meet all requirements of the law; but the standard of the land is, for our purposes, the inch, and I for one should be sorry to see it abolished.

If, as I am informed, some of our schools of science see fit to make their method of teaching dependent on the metre and its divisions, to the exclusion of the ordinary nomenclature of the land, their wisdom may well be questioned. We need educated engineers, but we need them educated in our mode of thought. The universities of the land are awake to the need of scientific education, and our sons are sent to them that they may learn what will be of the most use to them in active life. We wish them to learn the languages of other leading lands, but we insist that they shall know their own language. We would have them read the scientific languages also, but if for good reasons we choose to retain our technicalities, deeming them more convenient for our use, we also insist that they shall know how to use them in our business relations.

Impressed, as I am, with the insurmountable difficulties in the way of a change in our unit of measurement, even if that change was desirable, I cannot help thinking that, if the hypothetical New Zeal

APPENDIX B.

Comparison of Screw Threads in use.

FRANCE.								ENGLAND.				AMERICA.			
	Pitch in millimetres.							Whitworth.				U. S. Standard.			
Diam. in mm.	French Railroads.	Denis Poulot.	Bodmer.	Vignole d'Armengaud. Diam.	Vignole d'Armengaud. Pitch.	Ducommun. Diam.	Ducommun. Pitch.	Diam. in inches.	Diam. in millimetres	Pitch in millimetres.	No. of threads per inch.	Diam. in inches.	Diameter in millimetres.	Pitch in millimetres.	No. of threads per inch.
3	—	—	0·5	—	—	3	0·5								
4	—	—	0·5	—	—	4	0·75								
5	—	—	0·83	5	1·4	5	0·75	$\frac{3}{16}$	4·7	1·058	24				
6	—	—	0·83	—	—	6	1	$\frac{1}{4}$	6·4	1 270	20	$\frac{1}{4}$	6.4	1.270	20
7	—	1·50	1·00	—	—	7	1·25								
8	1·50	1·50	1·00	7·5	1·6	8	1·25	$\frac{5}{16}$	7 9	1·410	18	$\frac{5}{16}$	7·9	1·410	18
9	—	1·50	1·25	—	—	9	1·5								
10	1·50	1·50	1·25	10	1·8	10	1·5	$\frac{3}{8}$	9·5	1·585	16	$\frac{3}{8}$	9·5	1·585	16
12	1 50	1·75	1·47	—	—	12	1·75	$\frac{7}{16}$	11 1	1·815	14	$\frac{7}{16}$	11·1	1 815	14
14	—	1·75	1·73	12·5	2·0			$\frac{1}{2}$	12·7	2·120	12	$\frac{1}{2}$	12·7	1·95	13
15	2·00	·00	1·73	15	2·2	15	2	$\frac{9}{16}$	15 9	2·309	11	$\frac{9}{16}$	14·26	2·120	12
18	2·00	2 00	2 00	17·5	2·4	18	2 5					$\frac{5}{8}$	15·6	2·309	11
20	2·00	2·50	2·50	20	2 6	20	2·5	$\frac{3}{4}$	19 1	2·54	10	$\frac{3}{4}$	19·1	2·54	10
23	2·50	2·50	—	22·5	2·8	23	3·0	$\frac{7}{8}$	22·2	2·820	9	$\frac{7}{8}$	22·2	2·820	9
24	—	—	2·78												
25	3·00	3·00	—	25	3·00	25	3·0	1	25·4	3·175	8	1	25·4	3·175	8
26	—	—	2·78	—	—										
28	3·00	3·00	3 125	—	—	28	3	$1\frac{1}{8}$	28·6	3·629	7	$1\frac{1}{8}$	28·6	3·629	7
30	3·00	3 50	3·125	30	3 4	30	3·5								
32	3·00	3·50	3·58	—	—	32	3·5	$1\frac{1}{4}$	31·8	3·629	7	$1\frac{1}{4}$	31·8	3·629	7
34	—	—	3·58	—	—										
35	3·50	4·00	—	35	3·8	35	4	$1\frac{3}{8}$	34·9	4·225	6	$1\frac{3}{8}$	34·9	4·225	6
37	—	—	—	—	—	37	4								
38	3·50	4 00	4·18	—	—			$1\frac{1}{2}$	38·1	4·225	6	$1\frac{1}{2}$	38 1	4·225	6
40	4·00	4 50	—	40	4·2	40	4								
42	—	—	4.18	—	—	42	4·5	$1\frac{5}{8}$	41·3	5·080	5	$1\frac{5}{8}$	41·3	4 61	$5\frac{1}{2}$
45	—	—	—	45	4·6	45	4·5	$1\frac{3}{4}$	44·5	5·080	5	$1\frac{3}{4}$	44·5	5.08	5
46	—	—	5·00	—	—										
47	—	—	—	—	—	47	5	$1\frac{7}{8}$	47·6	5·650	$4\frac{1}{2}$	$1\frac{7}{8}$	47·6	5·08	5
50	—	—	5·00	50	5	50	5	2	50·8	5·650	$4\frac{1}{2}$	2	50·8	5·650	$4\frac{1}{2}$

ander, when he has done contemplating the ruins of St. Pauls, from the sole remaining vestige of London bridge, in the far-off distance of the future, shall seek from the ruins of a mighty city to learn the nature of a nation's greatness, and shall measure its length and its breadth, as did Prof. Piazzi-Smyth the Pyramids, he will find its unit of measurement to have been the inch.

APPENDIX A.

RELATIONS OF THE METRE AND THE INCH.

Millimetres.	Inch.	Inch.	Millimetres.	Millimetres.	Inch.	Inch.	Millimetres.	Inches.	Millimetres.
1	·03937			13	·51182			2	50·76
		1/16	1·58	14	·5512				
2	·07874					9/16	14·26	3	76·14
3	·11811			15	·59056				
		1/8	3·17			5/8	15·85	4	101·52
4	·15748			16	·62994				
		3/16	4·73	17	·66931			5	126·9
5	·19685					11/16	17·43		
6	·23622			18	·70868			6	152·28
		1/4	6·34	19	·74805				
7	·2756					3/4	19·02	7	177·66
		5/16	7·92	20	·78742				
8	·31497					13/16	20·60	8	203·44
9	·35434			21	·82679				
		3/8	9·51	22	·86616			9	228·42
10	·39371					7/8	22·19		
11	·43308			23	·90553			10	253·80
		7/16	11·09			15/16	23·77		
12	·47245			24	·9449			11	279·18
		1/2	12·68	25	·98424				
						1	25·38	12	304·56

Centimetres.	Metre.	Inches.
1	·01	·39371
2	·02	·78742
3	·03	1·18113
4	·04	1·5748
5	·05	1·9685
6	·06	2·3622
7	·07	2·756
8	·08	3·1497
9	·09	3·5434

Decimetre.	Metre.	Inches.
1	·1	3·9371
2	·2	7·8742
3	·3	11·8113
4	·4	15·7484
5	·5	19·6855
6	·6	23·6226
7	·7	27·5596
8	·8	31·4976
9	·9	35·4339

1 metre = 39·371 in.

[Entered according to the act of Congress, in the year 1873, by John Richards, in the office of the Librarian of Congress at Washington.]

THE PRINCIPLES OF SHOP MANIPULATION FOR ENGINEERING APPRENTICES.

By J. Richards, Mechanical Engineer.

(Continued from page 262.)

The Arrangement of Engineering Establishments.

The first and, perhaps, the most important matter of all in founding engineering works is that of arrangement. As a commercial consideration affecting the cost of manipulation, and the cost of handling material, the arrangement of an establishment may determine in a large degree the profits that may be earned, and upon this matter of profits depends the existence of such works.

Aside from the cost or difficulty of obtaining ground sufficient to carry out plans for engineering establishments, the diversity of their arrangement that is met with is no doubt owing mainly to a want of reasoning from general principles in the preparation of plans.

The similarity of the operations carried on in all works directed to the manufacture of machinery, and the kind of the knowledge that is required in planning and conducting such works, would lead us to suppose that at least as much system would exist in machine shops as in other manufacturing establishments, which is certainly not the case in America, and hardly the case in Europe.

There is, however, this difference to be considered: that whereas most other establishments are arranged at the beginning for a specific amount of business, machine shops generally grow up around a nucleus, and are gradually extended as their reputation and the demand for their productions increase; besides, the variety of operations required in an engineering establishment are apt to lead to a confusion in arrangement, which is too often promoted, or at least not prevented, by the want of a true estimate of the cost of handling and moving material.

The material consumed by an engineering establishment consists mainly in iron, fuel, sand and lumber. These articles or their product is, during the processes of manipulation, continually approaching the erecting shop, from which finished machinery is discharged after its completion. This constitutes the erecting shop, as a kind of focal centre of the works, which should be the base of a general plan for arrangement. This established, and the foundry, smithy, finish-

ing and pattern shops, regarded as feeding departments to the erecting shop, it follows that the connections between the erecting shop and the other departments should be as short as possible and such as to allow free passage for the material and communication between the managers and workmen. These conditions would suggest a central room for erecting, with the various departments for casting, forging and finishing, radiating from the erecting shop like the spokes of a wheel, or, what is nearly the same, branching off at right angles on either side and at one end of a hollow square, leaving the fourth side of the erecting room to front on a street or road, permitting free exit for the machinery when completed.

By an arrangement of this kind the material is received on the periphery, as we may say, the product discharged in the centre, and the communication between departments is the most direct that it is possible to have. By observing the plans of the best establishments of modern arrangement, especially those in Europe, the apprentice will see that this system is approximated in many of them, especially in establishments devoted to the manufacture of some special class of work.

Handling and moving material is in fact the leading object to be considered in the arrangement of engineering works. The constructive manipulation can be watched and estimated, and faults detected by comparison, but handling, like the designs for machinery, is a more obscure matter, and may be greatly at fault without the defects being apparent to any but those who are highly skilled.

Presuming an engineering establishment to consist of one-story buildings, and the main operations to be conducted on the ground level, the only vertical lifting to be performed will be in the erecting room, where the parts of the machines are assembled. This room should be reached in every part by an over-head travelling crane, that can not only be used in turning, moving and placing the work, but in loading it upon cars or wagons.

Castings, forgings, and general supplies of the erecting room can be easily brought from the other departments on trucks without the aid of the motive power; so that the erecting and foundry cranes will do the entire lifting duty required in any but very large establishments.

The auxiliary departments, if disposed about an erecting shop in the centre, should be so arranged that material which has to pass through two or more departments can do so in the order of the processes, and

without having to cross the erecting shop. Casting, boring, planing, drilling and fitting for examples, should follow each other and the departments be arranged accordingly.

Whenever a casting is moved twice over the same track or moved and returned over the same course, it shows fault of arrangement, and useless expense. The same rule applies to any kind of material. A great share of the handling about an engineering establishment is avoided if the material can be received on a higher level than the working floors; if, for instance, coal, iron and sand is received from railway cars at an elevation sufficient to allow it to be deposited where it is wanted by its gravity, it is equivalent to saving the power required to raise it again to such a level if the material was delivered on the ground, for if the coal, iron or sand is not to be raised it has to be moved horizontally and piled up, which amounts to the same thing in the end.

It is not proposed to consider the details of shop arrangement further than to furnish a clue to the general principles that should be consulted in devising plans of arrangement.

Such general principles are much more to be relied upon than even experience in the arrrangement of shops, because all experience must be gained in connection with special conditions that often warp and prejudice the judgment and leads to errors in forming plans where the conditions are different from those where such experience was gained.

Generalization of Shop Processes.

Having thus far treated of such general principles and facts connected with practical mechanics as might properly precede and be of use in the study of actual manipulation in the workshop, we come next to casting, forging, and finishing, with other details that involve manual as well as mental skill, and to which I will apply the term "processes," for want of one more applicable.

As these shop processes or operations are more or less connected, and run one into the other, it will be necessary at the beginning to give a short summary of them, stating the general object of each, that may serve to render the detailed remarks more intelligible to the apprentice as he comes to them in consecutive order.

Designing or generating the plans of constructing machinery may be considered the leading element in engineering manufactures or machine construction, the one to which all others are subordinate, both in order and importance, and is that branch to which engineering knowledge is especially directed.

Designing consists, first, in assuming certain results, and, secondly, in conceiving of mechanical agents to produce these results.

It comprehends the geometry of movements, the disposition and arrangement of material, the endurance of wearing surfaces, adjustments, and symmetry; in short, all the conditions of machine operation and machine construction. This subject will be again treated of in another section relating to shop processes.

Drafting, or drawing, as it is more commonly called, is a means by which mental conceptions are conveyed from one person to another; it is the language of mechanics, and takes the place of words, which are insufficient to convey mechanical ideas in an intelligible manner.

Drawings represent and explain the machinery to which they relate as the symbols in algebra represent quantities, and in a degree admit of the same modifications and experiments to which the machinery itself could be subjected if here already constructed.

Drawings are also an important aid in developing designs or conceptions. It is impossible to conceive of, and retain in the mind, all the parts of a complicated machine and their relation to each other without some aid to fix the various ideas as they arise, and keep them in sight for comparison; like compiling statistics, the footings must be kept at hand for reference, and to determine the relation that one thing may bear to another.

In the workshop, the objects of drawings are to communicate plans and dimensions to the workmen, and to enable a division of the labor so that the several parts of a machine may be operated upon by different workmen at the same time, and to enable classification and estimates of cost to be made, and records kept.

Drawings are in fact the base of shop system, upon which depends not only the accuracy and uniformity of what is produced, but also, in a great degree, its cost.

Complete drawings of whatever is made are now considered indispensable in the best regulated establishments: yet we are not so far removed from a time when most work was made without drawings, but what we may realize their importance by contrasting the present with the system that existed but a few years ago, when to construct a new machine was a great undertaking, involving generally many experiments and mistakes.

Pattern making relates to the construction of wooden models for the moulded parts of machinery.

Pattern making involves a knowledge of shrinkage and cooling

strains, the manner of moulding and proper position of pieces, when cast, to insure soundness in particular parts.

As a branch of machine manufacture, pattern making requires a large amount of special knowledge, and a high degree of skill; for in no other department is there so much that must be left to the discretion and judgment of the workmen.

Pattern makers have to understand drawings thoroughly, in order to reproduce them on the trestle boards with allowance for shrinkage; they must also understand moulding, casting, fitting and finishing, and should, as a department of machine manufacture, rank next to designing and drafting.

Founding and casting relates to forming parts of machinery by pouring melted metal into moulds, the force of gravity alone being sufficient to press or form it into even complicated forms.

As a process for shaping such metal as is not injured by the high degree of heat required in melting, moulding is the cheapest and most expeditious of all means for shaping or forming material, for forms of regular outline, while the importance of moulding in producing irregular forms is such that without this process the whole system of machine construction would have to be changed.

Founding operations are divided into two classes, known technically as green sand moulding, and loam or dry sand moulding; the first, when patterns or duplicates are used to form the moulds, and the second, when the moulds are built by hand without the aid of complete patterns.

Founding involves a knowledge of mixing and melting metals such as are used in machine construction, the preparing and setting of cores for the internal displacement of the metal, cooling and shrinking strains, chills, and many other things that are more or less special, and can only be learned and understood from actual observation and practice.

Forging relates to shaping metal by compression or blows when it is in a heated and softened condition; as a process it is an intermediate one between casting and what may be called cold treatment.

Forging also relates to welding or joining pieces together by sudden heating that melts the surface only, and then by forcing the pieces together while in this softened or semifused state.

Forging also includes, in ordinary practice, the preparation of cutting tools, and tempering them to various degrees of hardness as the nature of the work for which they are intended may require; also

the construction of furnaces for heating the material, and mechanical devices for handling it when hot, with the various operations for shaping, which, like casting, can only be understood when seen.

Finishing and fitting relates to giving true and accurate dimensions to the parts of machinery that come in contact with each other and are joined together or move upon each other, and consists in cutting away the surplus material that has to be left in founding and forging, because of the heated and expanded condition in which the material is treated in these last processes.

In finishing, the material is operated upon at its normal temperature, in which condition it can be handled, gauged or measured, and will retain its shape after it is fitted.

Finishing comprehends all operations of cutting and abrading, such as turning, boring, planing and grinding, also the handling of material; it is considered the leading department in shop manipulation, because it is the one where the machinery is organized and brought together. The fitting shop is also that department to which the drawings especially apply, and other preparatory operations are usually made subservient to the fitting.

Shop system may also be classed as a branch of engineering work; it relates to the classification of machines and their parts by symbols and numbers, to records of weight and the cost of cast, forged and finished parts, and apportions the cost of finished machinery among the different departments of the works.

Shop system also includes the maintenance of standard dimensions, the classification and cost of labor, with other matters that partake both of a mechanical and a commercial nature.

In order to render their study more easy for the apprentice, I will, in treating of shop processes, change the order in which they are named in the summary. Designing, and many matters connected with the operation of machines, will be more easily learned and better understood after having gone through with what may be called the constructive operations, such as involve manual skill.

Mechanical Drawing.*

Drawing may in some regards be said to bear the same relation to mechanics that writing does to literature, but the analogy is by no means

* The 'substance' of this article appeared in a former number of the Journal last year, but its revision and connection with the series from which it was taken, for the first publication, will warrant its reproduction. W. H. W.

complete; a person may copy a manuscript or write from dictation about what he does not understand, but a mechanical draftsman cannot make drawings of a machine he does not understand; at least he can not do so in the true capacity of a draftsman and a mechanic.

Geometrical drawing is not an artistic art so much as it is a constructive mechanical one; displaying the parts of machinery on paper, is much the same in principle and just the same in practice, as measuring and laying out work in the workshop.

Artistic drawing is addressed to the senses, geometrical drawing is addressed to the understanding. Geometrical drawing may, however, include artistic skill, not in the way of ornamentation, but to convey an impression of neatness and completeness, that has by common custom been assumed among engineers, and which conveys to the mind an idea of competent construction in the drawing itself, and also in the machinery which is represented.

Artistic effect in drawings is easy to learn, and through a desire to make pictures, the beginner is often led to neglect that which is more important in the way of accuracy and a judicious arrangement of the drawing.

It is easy to learn "how" to draw, but is far from easy to learn "what" to draw; let this be kept in mind, not in the way of discouraging effort in learning "how" to draw, for this must come first, but in order that the objects and true nature of the work will be understood.

The engineering apprentice as a rule, has a desire to make drawings as soon as he begins his studies, and there is not the least objection to his doing so, in fact there is a great deal gained by illustrating movements and the details of machinery at the same time of studying the principles. Such drawings, if made, should always be finished and carefully inked in, and memoranda made on the margin of the sheets with the date and the conditions under which the drawings was made. The sheets should be of uniform size, not too large for a portfolio, and carefully preserved, no matter what their character.

An apprentice who will preserve his first drawings in this manner, will some day find himself in possession of a souvenir that no consideration would cause him to part with.

For an outfit procure two drawing boards, forty-two inches long and thirty inches wide, to receive double elephant paper; have the boards plain without cleets, or any ingenious devices for fastening

the paper, and made from thoroughly seasoned lumber at least one and one-fourth inches thick.

Two boards are required, so that one may be used for sketching and drawing details, which if done on the same sheet with elevations, dirties the paper, and is apt to lower the standard of the finished drawing by what I will term bad association.

Details and sketches should, when made on a separate sheet, be to a larger scale than on the elevations; by changing from one scale to another the mind is schooled in proportion, and the conception of sizes and dimensions is more apt to be based upon the finished work than the drawing itself.

In working to regular scales, such as half-eighth or sixteenth size, it is a good plan to use a common rule, instead of graduated scales; there is nothing more convenient for a mechanical draftsman than to be able to resolve dimensions into various scales, and the use of a common rule for fractional scales trains the mind so that the computations come naturally and after a time almost without effort.

Use a plain T square with a parallel blade fastened on the side of the head, but not inbedded into it; in this way the set squares can pass over the square head in working at the edges of the drawing; it is something strange that a drafting square should ever have been made in any other manner than this, and still more strange that people will use squares that do not allow the set squares to come near to the edge of the board.

A bevel square is often convenient, but should be an independent one; a T square that has a movable blade is never fit for general use; combinations in drafting instruments, no matter what their character, should be avoided; such combinations, like those in machinery, are generally mistakes, and effect just the reverse of what is intended.

For set squares, or triangles, as they are sometimes called, no material is so good as guttapercha; such squares are hard, smooth, impervious to moisture, and contrast with the paper in color; they will also wear longer than those of wood.

If wood squares are used, pear wood is best, because of its flexibility. A coat or two of shellac varnish improves such squares by making them smooth and preventing their derangement by moisture.

For instruments, avoid everything of the elaborate or fancy kind; such sets are for amateurs, not engineers. It is best to procure at first only such instruments as are really required, of the best make, and then to add others as necessity may require; in this way experience will often suggest modifications.

One pair each of three and one-half inch and five inch compasses, two ruling pens, two pair of spring dividers, for pen and pencils, a triangular boxwood scale and common rule, and a hard pencil, are the essential instruments for machine drawing.

At the beginning, when "scratching out" will probably form an item in the work, it is best to use Whatman's paper, or the best roll paper, which, of the best manufacture, is quite as good as any other for drawings that are not water-shaded.

In mounting sheets that are likely to be removed and replaced, for the purpose of modification, as working drawings generally are, they can be fastened very well by small copper tacks driven along the edges at intervals of two inches or less; the paper can be very slightly dampened before fastening in this manner, and if the operation is carefully performed the paper will be quite as smooth and convenient to work upon as though it were pasted down; the tacks can be driven down so as to be flush with, or below the surface of, the paper, and will offer no obstruction to the squares.

If a drawing is to be elaborate, or is to remain long upon the board, the paper should be pasted down. To do this, first prepare the mucilage, and have it ready at hand with some slips of absorbent paper about one inch wide. Dampen the sheet on both sides with a sponge, and then apply the mucilage along the edge, for a width of one-half inch; then set the edge of the board on the floor, so that it will lean against the desk at steep angles. In this position the paper can be applied without assistance. Then, by placing the strips of paper along the edge and rubbing over them with some smooth, hard instrument, the edges are pasted firmly to the board; the paper slips taking up a part of the moisture from the edges, which are longest in drying. If left in this condition, the centre would dry first, and the paper be pulled loose at the edges by contraction before the paste had time to dry. It is therefore necessary to pass over the centre of the sheet with a wet sponge at intervals until the edges adhere firmly, when it can be left to dry, and will be tight and smooth. In this operation much depends upon the judgment of the learner, and much will be learned by practice. One of the most common causes of trouble in mounting is in not having the mucilage thick enough; when thin, it is absorbed by the wood or the paper, and is too long in drying; it should be as thick as it can be applied with a brush, and made from clean gum Arabic or tragacanth; glue is not so good.

Thumb-tacks are of but little use in mechanical drawing except for

the most temporary purposes, and can very well be dispensed with altogether; they injure the drafting boards, obstruct the squares, disfigure the sheets.

To be continued.

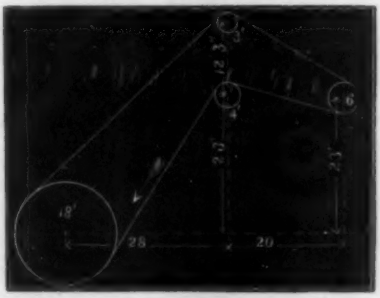
BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from Vol. LXVI, page 410.)

Mr. H. W. Curtis, of this city, furnishes the following:

"We have at our works a 20-inch single leather belt, 167 ft. long, having a 3½-inch single leather belt cemented and riveted on its outside face at either edge, and transmitting the power of a 20-inch diam., 48-inch stroke, horizontal Corliss engine. It is arranged to give power directly to three shafts, each in a separate room, from which the power is further conveyed, by means of vertical belts, to the other parts of the factory. The lower fold of this belt extends from the fly-wheel over a pulley 4 ft. in diameter (see cut), situated



28 ft. from and 23 ft. above the horizontal line of the engine. The upper fold is carried 12 ft. 3 in. higher, and over a pulley 3 ft. in diameter, situated directly above the 4-foot pulley.

"The main receiving pulley is 6 ft. diameter, situated in an adjacent building, 48 ft. horizontally distant, having its center on a level with that of the 4-foot pulley.

"The fly-wheel is 18 ft. diameter, and runs 60 revolutions per minute, giving a velocity to this belt of 3392 ft. per minute, and was calculated to give 125 horse-power on the three pulleys collectively, in the proportion of 80 on the 6-foot pulley, 24 on the 4-foot pulley, and 21 on the 3-foot pulley. This would make 70·6 square feet of belt per minute per horse-power on the 6-foot pulley, 235·55 square

feet on the 4-foot pulley, and 292·2 square feet on the 3-foot pulley. If considered as a 27-inch belt, it would be working at 61 square feet per minute per horse-power.

"This belt has worked up to 125 horse-power, as proven by indicator cards taken from the engine, which subjects the lower or drawing fold of the belt to a tensile strain of 1216 lbs., or 45 lbs. per inch of width, allowing 7 inches for the 3½-inch strips, making the belt equal to one of a single thickness 27 inches wide.

"This belt has been running nine months; its upper fold is very slack, the longest span is 50 ft., at an angle of 45°, having a sag of 20 in. to 24 in., and it has given entire satisfaction during that time. We have also three other belts, with similar strips on their outer faces. These belts were all tried 'single' at first, but would not do the work required of them. The first is 20 in. wide, taking power from a pulley 4 ft. in diameter to 3 ft. in diameter, situated 12 ft. 10 in. directly above. The next is 16 in. wide, taking the greater part of the power from the 20-inch-belt, by means of a 40-inch pulley, to one 24 in., situated 12 ft. 6 in. directly above. These belts were put on at the same time as the main belt, and after trying them five days, running only part of the machinery, and that with insufficient power, we thought it best to try the strips. The result was that with the strips they have driven all the machinery connected with them, giving no trouble whatever, and have not been tightened more than once in the time named above.

"The next is an 8-inch belt, driving a pump, the piston of which is 4 in. diameter, 12 in. stroke, is double acting, and makes 24 strokes per minute. The pulley on the crank shaft of pump is 22 in. diameter, and this is driven by a 7-inch pulley, situated nine feet below and five feet from the perpendicular line of the pump; both pulleys are covered with leather. The pump lifts water 12 ft., through a 2½-inch pipe, and forces it 80 ft. more of vertical height through 123 ft. of 2-inch pipe.

"A single leather belt, 8 in. wide, was first applied, but it would not drive the pump at all. It was thoroughly tried, by being drawn so tightly that it parted at one of the splices in a few minutes. It was then provided with strips, one on each edge, 1½ in. wide, and put on again, driving the pump successfully. It runs about three hours each day, and has not been tightened in five months.

"From the above results it is plain to see that our experience with belts of this character has been very satisfactory thus far; and we do

think that belts made heavier and stronger on their edges conform to the convexity of pulleys better, and that the same weight of leather will drive more and keep straighter than in any other form. We do not, however, recommend belts, strengthened by narrow strips on their outer faces, for running at a high speed over very small pulleys; in such places only light belts, of an even thickness, should be used."

A Sheet Iron Belt —A lathe used for turning rolling-mill rolls, compound geared, has a 48-inch pulley on it; this is driven by an 18-inch pulley, on the counter shaft, which makes 120 revolutions per minute, and is 8 ft. from the 48-inch pulley, measured from center to center. Both pulleys of iron smoothly turned on faces.

A 7-inch double leather belt was used on these pulleys, but would slip when the turning-tool became dull.

This belt was replaced by one made of Russia sheet iron, same as used for stove pipes and parlor stoves, and was rivetted together in the ordinary way; it was seven inches wide and was two inches longer than the leather belt. This extra length made up for the want of elasticity in the iron.

During one year's steady run this iron belt could not be slipped, even when a heavy "cut" on a 25-inch roll was taken, which broke a "Sanderson" steel tool having a section of $2 \times 2\frac{1}{2}$ inches, a cutting surface of $2\frac{1}{2}$ inches, a feed of $\frac{1}{8}$ inch per revolution, and an overhang of 4 inches. JOHN SPIERS, Worcester, Mass.

New Proof of the Metallic Character of Hydrogen.—MM. Troost and Hautefeuille have lately completed an important research relative to the compounds formed by hydrogen with certain metals, particularly potassium and sodium. They find that hydrogen unites definitely with both of these metals, forming compounds containing two atoms of the metal to one of hydrogen. Heated to 200° with hydrogen, potassium unites with it, producing a compound which is decomposed again at 900°. Sodium also unites with hydrogen at 200°, but the resulting compound is completely decomposed at 400°. Both these hydrides present all the characters of amalgams; they have a metallic lustre and show the general physical appearance of a metal. This fact furnishes an additional proof of the metallic character of hydrogen, these compounds being quite analogous to the palladium hydrides discovered by Graham. Potassium and sodium hydrides are true alloys, so far, at least, as their physical properties are concerned.

Chemistry, Physics, Technology, etc.

ON THE RUSSIAN COALS FROM THE BASIN OF THE RIVER DON, INVESTIGATED BY MESSRS. SCHEURER-KESTNER AND MEUNIER-DOLFUS.

By Chief Engineer Isherwood, U. S. Navy.

The carboniferous strata of the basin of the River Don, in Russia, contain immense deposits of coal, which are now being mined, and will doubtless soon be advantageously substituted for English coal along the shores of the Black and Mediterranean Seas. Some of this coal has an exceptional purity, yielding, even when burned in large quantities, only two or three per centum of ash. Its qualities have been carefully investigated by A. Scheurer-Kestner and Charles Meunier-Dolfus, who have accurately determined its ultimate chemical composition and its total calorific effect when consumed in oxygen, employing for the latter purpose an improved Favre and Silbermann calorimeter. They made similar determinations, also, for a Russian lignite, from Toula, in the Government of Riazan.

The calorific effects thus obtained have an interest additional to their use in determining the commercial value of the coal, as furnishing a test of the reliability of that law of Dulong which assumes the calorific effect of coal free from hygroscopic moisture to be the sum of the calorific effects of its combustible elements less the portion of hydrogen required to form water with the whole of its oxygen. The correctness of this law had previously been extensively investigated, by Messrs. Scheurer-Kestner and Meunier-Dolfus, for many of the coals of the upper Rhine, for two Welsh coals, and for six lignites of Bohemia, the lower Alps and the mouths of the Rhone. The result was that the coals gave experimentally a calorific effect from three to twelve per centum higher than was obtained by calculation according to Dulong's law. Of the six lignites, one gave experimentally five per centum less calorific effect than was due to the calculation; but the remaining five gave a greater calorific effect than was due to the calculation by respectively 3·0, 12·7, 20·9, 13·5 and 8·3 per centum.

The Russian coals of the Don differed from the coals just cited in giving experimental calorific effects nearly the same as were derived from calculation. For instance, of the three coals examined,

one gave an experimental calorific effect 0·8 per centum higher than the calculated one; another gave an experimental calorific effect 0·9 per centum lower than the calculated one; while the experimental calorific effect of the third was 1·5 per centum higher than that due to the calculation. To these may be added an anthracite examined by Messrs. Favre and Silbermann, which gave experimentally the calorific effect due to the calculation. Some cellulose examined by Messrs. Scheurer-Kestner and Meunier-Dolfus gave a similar result; that is to say, the calorific effect given by calculation according to Dulong's law was obtained by experiment in the calorimeter.

Messrs. Scheurer-Kestner and Meunier-Dolfus are confident of the accuracy of their calorific determinations to within one per centum, but the experimental inquiry is a difficult one, and the direct result requires somewhat uncertain corrections of much magnitude for disturbing causes. Again, should the ultimate analyses of the coals be but very slightly erroneous in assigning too little hydrogen, and it is almost impossible to so completely isolate it as to ascertain its full quantity, the inferiority of the calculated to the experimental calorific effect would nearly vanish.

A notable difference between the coals and lignites is that the coals gave experimentally a calorific effect not only greater than the calculated calorific effect according to Dulong's law, but greater than is due to the sum of the calorific effects of the elements without deduction of the hydrogen required to form water with the oxygen; while the lignites (with one exception), although giving experimentally greater calorific effects than are due to the calculation, gave less calorific effects than are due to the sum of the calorific effects of the elements.

If, however, the accuracy of the experimental results be admitted, then, starting from the fact of the equality of the experimental and calculated calorific effects of cellulose, and assuming lignite and coal to be formed principally from cellulose, the conclusion is reached, as regards heat of combustion, that cellulose, lignite and coal form a series in which the cellulose, when transforming into lignite and into coal, *undergoes a modification accompanied by absorption of heat*, the absorption being much more considerable for the coal than for the lignite.

The problem is one of the highest industrial importance, and its satisfactory solution requires much more extended trials to be made by other apparatus and by other experimenters. Any difference that

may thus be finally established between the experimental and the calculated results will probably be but very small, and confined almost entirely to the volatile portion of the coal which, even if composed of the same ultimate elements in the same proportion, may have them combined into very different proximate principles, requiring different quantities of heat for their volatilization and decomposition. In the meanwhile, the results of calculation according to Dulong's law, which is one based on rational considerations, may be accepted as giving at least *relative* determinations with sufficient accuracy for the purposes of practice.

The following table contains the results of the investigation of the ultimate composition and calorific effects of the coals from the basin of the Don, and of the lignite from Toula. The calorific effects are given, first, experimentally, for the crude coals and lignite; that is to say, for one pound of these substances, including their hygroscopic water and ash. Next, experimentally, for one pound of what remains of the coals and lignite after deduction of their hygroscopic water and ash. Then, by calculation, for the sum of the calorific effects of the ultimate elements of one pound of what remains of the coals and lignite after deduction of their hygroscopic water and ash. And, finally, by calculation according to Dulong's law, for one pound of what remains of the coals and lignite after deduction of their hygroscopic water and ash.

The calorific effects are expressed by the number of pounds of water, at the temperature of 32 degrees Fahrenheit, which would be raised one degree Fahrenheit under the pressure of 29·92 inches of mercury, by the heat developed during the complete combustion of one pound of the substance, supplied at the temperature of 32 degrees Fahrenheit, and having the products of its combustion cooled down to the same.

The percentum by weight, and the character of the coke derived from the above coals by calcination in a retort, are as follows:

The Groucheaski anthracite gave 91 per centum of feebly agglomerated residue.

The Mioucki coal gave 80 per centum of very hard coke.

The Galoubosski coal gave 60 per centum of well agglomerated coke, but less tenacious than the preceding.

The lignite was brown in color, and broke into lamellated fragments, with sharp edges and conchoidal faces.

	Composition of the Coals of the Don, in per centum of their weight.						Composition of the Lignite of Toula, in per centum of its weight.	
	Anthracite. Groucheuski.		Coal. Mioucki.		Coal. Galeubouski.		Lignite. Toula.	
	Crude.	Less Ash and Water	Crude.	Less Ash and Water	Crude.	Less Ash and Water	Crude.	Less Ash and Water
Carbon	91·20	96·66	89·97	91·45	77·47	82·67	54·37	73·72
Hydrogen	1·27	1·35	4·43	4·50	4·75	5·07	4·49	6·09
Oxygen and Nitrogen, with trace of Sulphur	1·88	1·99	3·98	4·05	11·48	12·26	14·89	20·19
Ash	1·57	.....	0·23	.....	1·42	.....	16·86	.....
Hygroscopic water	4·08	.....	1·39	.....	4·88	.....	9·39	.....
Total	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
	Calorific effects.		Calorific effects.		Calorific effects.		Calorific effects.	
Pounds of water, by experiment, raised 1° F. by one pound of the crude coal and lignite	14139		15383		13509		10429	
Pounds of water, by experiment, raised 1° F. by one pound of what remains of the coal and lignite after deducting ash and water	14866		15651		14438		13537	
Pounds of water, by calculation according to the sum of the calorific effects of the elements, raised 1° F. by one pound of what remains of the coal and lignite after deducting ash and water	14899		16103		15181		14513	
Pounds of water, by calculation according to Dulong's law, raised 1° F. by one pound of what remains of the coal and lignite after deducting ash and water	14742		15791		14227		12944	

The following table contains the composition and calorific effects of two first-class Welsh steam coals, with which the Russian coals will be brought in competition in the Black and Mediterranean Seas. The Welsh coals were investigated by Messrs. Scheurer-Kestner and Meunier-Dolfus with the same apparatus and in the same manner as in the case of the Russian coals; the results, therefore, are strictly comparable.

Name of Coal.	Composition of the Welsh Coals, less Ash and Hygroscopic Water, in per centum of their weight.			Calorific effect, by experiment, in pounds of water raised 1° Fahr. by one pound of what remains of the coal after deducting ash and water.
	Carbon.	Hydrogen.	Oxygen and Nitrogen.	
Bwlf	91·08	3·83	5·09	15804
Powell	92·49	4·04	3·47	16108

CONVECTION APPLIED TO THE DETECTION OF HEAT.—II.

By LeRoy C. Cooley, Ph. D.

Since the publication of a former paper on this subject in this Journal (Vol lxvi, p. 343), various experiments have brought about a change in the form of the convection thermoscope, by which its sensibility is increased, and its adaptation to a wider range of experiments secured. But, before entering upon any description, I hasten to call attention to the following extract from a lecture by the Earl of Rosse, at the Royal Institution, on May, 1873, from which it will be seen that something in the same direction has been done by the eminent physicist Joule. The original paper is not within my reach, nor have I seen any full report of the Earl's lecture. This extract was copied from a printed extra copy of the lecture, and kindly sent to me, since the appearance of my former paper, by Dr. Alfred M. Mayer, who received it from the hand of the Earl in London:

"Prof. Joule, in 1863, by means of a cylindrical glass vessel, divided in a vertical direction by a blackened pasteboard diaphragm, which extended to within one inch of the cover and of the bottom of the vessel, and in the upper of which spaces was delicately suspended a magnetized sewing needle furnished with a glass index, was able to detect the heat from a pint of water heated to 30° C., placed in a pan at nine feet distance; also that of a moonbeam admitted through an opening in a shutter as it passed across the apparatus."

The instrument which I have devised, while ignorant of Joule's experiments, is so different from that indicated by the above description, that I still feel justified in calling attention to it, and the more fully so since the simplicity of its construction, its sensibility and its cheapness combine to commend it to the favorable notice of those who have need of a sensitive thermoscope, without being able to command the expensive thermo-multiplier of Melloni.

In the original form of the instrument, a very light glass needle,

suspended in a horizontal position by a fine silk fibre, was enclosed in a cylindrical glass case. A very gentle air-current, such as the presence of a warm body occasions, acting upon the end of the needle thus arranged, will waft it along, and a horizontal graduated circle below may show the extent of the motion.

The torsion of the suspending fibre and the inertia of the needle are the two resistances to be overcome by the force of the air-currents before the needle can move. Evidently, with a needle of given weight, these resistances will be overcome most readily when the fibre is longest and finest, and when the needle is also of the greatest practicable length. Constructing the instrument accordingly, it was found that the needle refused to maintain any one position over the scale. Subject to the influence of external sources of heat, it would rest nowhere long. Even the presence of the experimenter was a disturbing element. This difficulty could be overcome only by changing the character of the chamber so that the interior may be protected from any sudden local change of temperature. A long and light needle, a long and delicate fibre for its suspension, and a chamber whose walls will protect its interior from the influences of surrounding sources of heat—these are the requisites in the construction.

Twelve inches was chosen to be the length of the needle. A glass tube, about one-fourth of an inch in diameter, was drawn out, while hot, until so small that the required length was little more than able to sustain its own weight when suspended. A disk of paper, three-sixteenths of an inch in diameter, was laid upon one end of this slender tube, and cemented there by a minute drop of wax.

This needle was suspended horizontally, with the plane of the disk vertical, by means of a single fibre of silk, about eighteen inches in length, extending upward in a long glass tube projecting from the top of the chamber for its protection.

The chamber is a double-walled box, measuring eighteen inches in length by four in width and six in height. Its inner walls and bottom are of glass; its outer walls and top are of wood, a glass window being inserted in each end. The two walls are separated by an air-space of about half an inch. And, finally, the whole exterior, except the windows at the end, is covered with gilt paper, that it may be a good reflector.

An opening in the top of the chamber above the needle-disk allows the introduction of objects into the neighborhood of the disk when their temperature is to be tested, but to adapt the instrument to ex-

periments with radiant heat another arrangement is added. Opposite the needle-disk an opening through both walls of one side of the chamber permits a conical reflector to project slightly into the interior. The small inner end of this reflector is about a half inch in diameter, and is closed air-tight by a disk of the thin glass used for microscopic purposes. This glass may be blackened if necessary. When not in use, the outer end of the reflector may be covered. The heat radiated from an object in front of the cone will be thrown upon the thin glass at the inner end. The gentle warmth of the glass will occasion air-currents within the chamber, by which the disk will be wafted toward the cone. A scale engraved upon a vertical glass, standing in front of the disk, enables the motions of the needles to be seen and compared.

The description of two or three experiments from among the many made with this apparatus will suffice to show the delicacy of its indications.

A rectangular tin vessel, filled with water at a temperature of 95° F., and exposing a radiating surface of eight by ten inches area, was placed at a distance of twenty feet in front of the cone. The temperature of the interior of the thermoscope was 54° F. At the end of three minutes the needle was perceptibly in motion.

The needle having been stationary for twenty-seven minutes preceding, I seated myself at a distance of twenty feet in front of the cone, with my face toward it. The temperature of the interior of the instrument was 57° F. Five minutes afterward, on returning to the apparatus, the needle was found to have moved toward the cone.

The out-door temperature, one day, being 38° F., and that of the thermoscope within being 68° F., the cone was pointed toward a window twenty-one feet away. When the needle had been at rest for ten minutes the cone was uncovered. In eight minutes afterward a perceptible motion had occurred; the disk had moved *away from the cone*, indicating cold.

In attempting to use this instrument for lecture purposes, the slowness with which the needle returned to the zero of its scale after experiment was a source of annoyance, and its prompt return could be secured only at the expense of some degree of its sensibility. Among those tried were the following well-known methods of suspension:

A fine thread of spun glass, two feet long, was used in place of the silk fibre. The torsion of this thread will bring the needle to its zero with considerable promptness. Its sensibility is very much impaired,

but not to such an extent as to prevent its response to very delicate changes in the temperature of bodies which may be thrust into the chamber. Such experiments as those described in the former paper may be made very satisfactorily with this instrument; but for experiments with radiant heat the bi-filar mode of suspension is better. Two single silk fibres, parallel and near together, sustain the needle, and allow it to remain away from its zero only while under the influence of the heat currents.

The directive force of a magnet (Joule's method) was also tried. The needle being suspended by a single fibre of silk, a delicate magnet, made by taking a quarter inch in length from the fine end of a small sewing needle, and slightly magnetizing it, was placed under the centre. This instrument was less sensitive than either of the others. Moreover, when iron was used in any way as the source of heat, the magnetic influence could sometimes be detected, and thus tended to obscure the indications of the thermoscope.

A beam of light, from which the heat has been filtered, may be thrown through the thermoscope lengthwise of the needle, and, by means of a lens, may be made to form the image of the disk upon a screen. By this means the motion of the needle-disk toward or from the object, according as the temperature is higher or lower than that of the instrument, has been seen, at once and distinctly, by a large number of persons. Thus, the heat evolved by the fall of a hammer through a few inches upon a copper wire lying upon an anvil, may show itself to a large audience when the wire is thrust into the chamber. The heat, by the chemical action of a single drop of oil of vitriol with only its proper quantity of water, will show itself by the motion upon the screen, when a wire, after remaining a moment in the mixture, is thrust into the neighborhood of the disk. The cooling of the wire by evaporation, when moistened with ether, is shown by the disk-image flying away from it on the screen. Let a small copper wire pass through a cork, closing the opening in the top of the chamber down to a level with the disk, while its upper end, being bent into a horizontal direction, projects over the edge of the instrument. Apply the heat of a spirit lamp to the outer end of the wire. In less than a minute the disk will be seen moving toward the inner end of the wire, showing the transmission of heat by conduction.

THE METALLURGY OF THE FUTURE.

An Address delivered before the Society of Civil Engineers of France on the 9th of January, 1874, *by their President*, M. JORDAN.

[Translated from the "Revue Industrielle."]

(Continued from page 344.)

The science of molecular mechanics is yet in its infancy; and for this very reason it presents a rich field for investigation and experiment. We are already acquainted with iron, for example, in very many physical conditions. We have learned within a few years how to obtain it melted like steel and cast-iron. But how numerous are the things which yet remain for us to learn, in order to understand the properties of even these various states of iron; in order to explain the peculiarities which they present when viewed from the standpoint of construction; in order to establish the relation which should subsist between these different molecular states and the resistance of the metal under various strains; in order to have as definite a theory for working iron cold as for working it hot. This knowledge, which may be called the physics and the molecular mechanics of iron, is still very rudimentary. We have in our own ranks—and we may be proud of him—a learned engineer who was among the first to devote himself to the ascertaining of this knowledge; his researches upon the flowing of solids and upon the forging of metals, are destined to bear him rich fruit, especially in connection with the parallel series of experiments upon the resistances and the deformations of metals, which he has published with them. Will he permit me to express a regret that he has not decided to communicate to the engineering profession, through the agency of our own organization perhaps, the valuable data already in his possession, which would form so exceedingly valuable a basis for future investigations of the same sort?

Availing myself of this opportunity, I will attempt to lay before you a sketch of what I foresee in these molecular studies, at present unfortunately too much neglected. I will enter upon the subject through a phenomenon well kdown to every one. It is a matter of common knowledge that iron is capable of being welded; that if two pieces of iron be heated to a temperature, called for this very reason a welding heat, and then be pressed together, either by hammering or by energetic pressure, the two pieces will be firmly united; *i. e.*, welded together. Why is this? The only explanation which we can

find in the best works on chemistry or metallurgy is the following: "At a white heat, iron acquires the property of being welded, a property which it shares with the metal platinum only." But obviously there is no evidence here of any mysterious and special property of iron called weldability; there is only the effect of a very general cause, the manifestation of a molecular property elsewhere abundantly active in nature.

Take two pieces of ice, and a temperature just below zero, press them even very gently together; they become at once welded to each other. This is the phenomenon, first observed by Faraday and subsequently investigated in so fascinating a way by Thomson and Tyndall, which has received the name "regelation." Thomson explains it in the following manner: For all bodies, like water, which have the property of diminishing in volume as they liquefy, pressure, which tends to bring the molecules closer together, lowers the temperature of fusion. Consequently, when two pieces of ice are rubbed against each other, fusion takes place between the surfaces of contact, at a temperature below zero. Of course, as soon as the pressure ceases, solidification is again produced and the pieces are welded together.

It seems to me that the welding of iron is a phenomenon exactly similar to regelation. The two pieces of iron are brought to a white heat, that is to say, more or less near to the fusing point. The repeated blows of the hammer, or the pressure of the rolls, lowers the point of fusion and causes a superficial liquefaction of the parts in contact, and thus welds the masses together; and this, because, like water, iron dilates in passing from the liquid to the solid state. Many other metals are similarly endowed; they all therefore may be welded like iron, if other conditions do not come in to oppose the manifestation of this property. Platinum welds easily at a white heat because its non-oxidizable surface, like that of ice, takes on a superficial fusion. To weld iron successfully it is necessary that its surface should be clean, that is, free from oxide. Iron containing phosphorus welds more easily than pure iron, because its point of fusion is lower. Steel, which is more fusible still, welds at a lower temperature than iron, but the process is a more delicate one. Silver, too, like iron and platinum, has the property of expanding when it solidifies; but as it melts at a cherry red heat, it is easier to form it by casting than by welding. Bismuth and zinc are also included in the same class; but they are so very brittle near their fusing points that no one would think of attempting to weld them either by hammering or pressure.

Iron, in welding, therefore, only follows the example of water. The careful comparative study of these two bodies, even though at first sight apparently so dissimilar, cannot fail to furnish, for this reason, results of great interest to the metallurgist. I have lately read an excellent book by Mr. Tyndall, upon glaciers and the transformations of water, and I have been repeatedly struck with the great number of analogies presented by these two bodies. Indeed, I might almost say similitude, were not the fusing points of the two distant from each other more than fifteen hundred degrees centigrade.

When snow is at a temperature not too far below zero, children amuse themselves by making balls of this substance and increasing their size by rolling them upon the white layer beneath; the simple weight of the primitive ball being sufficient to cause the agglomeration of the successive layers. If a snowball be compressed in the hands a hard mass is obtained, which is at first white and opaque; if the pressure be increased a translucent mass results, and if it be very considerable, a piece of transparent ice is produced, care, of course, being taken to expel the traces of air entangled mechanically between the snow crystals.

Place fragments of ice, coarsely broken, in a mould furnished with a cover and compress them energetically, either by the blows of a hammer or by means of a press, and you will obtain, if the temperature of the mass be near 0°, a compact block which takes the exact form of the mould. Having moulds for roughing the block out and others for finishing it, you may stamp the ice so as finally to form an object of almost any desired form. In one of his celebrated lectures on heat, Mr. Tyndall made in this way a cable-link in the form of the figure eight. Pounded ice regelates better than snow, and therefore permits better the repetition of this last curious experiment. But even a snowball well compressed may be converted into the form of an elongated solid; and then, operating with care and slowly, one may, either by pressure or by a succession of slight blows, form it gradually into an ice-block of any desired form.

Now in what does all this differ from the work performed by the puddler when he forms his ball in the furnace by rolling together the crystals of iron which have come to nature there in the midst of the slag? when in shingling, the expulsion of the liquid scoria from between the crystals of iron is effected, either by pressure or by a blow; either under the hammer or within the squeezers? A piece of iron forged at a bright red heat seems to act like a viscous body; it

becomes extended in various directions, and in fact acts like the ice of a glacier, which flows along its bed, conforming itself to all its sinuosities. But the ice of a glacier is not viscous; it has been shown that this appearance is due to the continual formation of innumerable cracks, the surfaces being immediately united again by regelation, under the pressure of the superincumbent masses.

Even if iron can be forged at a red heat, we know that at this temperature it will not support severe traction. Iron wire, for example, cannot be passed through a draw plate at a high temperature, its resistance to traction being then too feeble. So it is with ice; if it can support a pressure, it cannot stand a tensional strain, but breaks without sensibly elongating.

Physicists, like Tyndall and Helmholtz, distinguish two kinds of ice; lake ice, which is formed by a regular crystallization on the surface of still water; and glacier ice, or compression ice, produced either from snow crystals or ice fragments, united into a single block by the effect of regelation. These two kinds of ice act very differently under the influence of an energetic compression. The former, or the crystalline ice, breaks throughout its mass into a great number of fragments; the latter, the amorphous or granular ice, changes its form and moulds itself anew, by a series of minute crackings scarcely to be perceived. So attempt to forge, without care, an ingot of iron or of steel, and you will cause it to crumble, because it is crystalline; but if you submit this ingot first to the operation of sweating, that is to say, if you heat it to the welding temperature and then, by an energetic pressure, you effect by regelation the welding together of the various crystals of the metal, you will then have a mass which can be forged without difficulty. Even the fragments of such a mass can be welded, although pieces of the primitive ingot are not weldable directly.

Iron made in the puddling furnace is crystalline. It becomes amorphous in the process of shingling and rolling. Steel cast at a temperature near its point of fusion and slowly cooled is also crystalline in the same way and for the same reason, as lake ice. I do not suppose it is necessary for me to say here that water and steel do not crystallize in the same system, nor to recall the fact that carbon and iron are isomorphous.

Again, both iron and cast steel, even after forging, by which all the cleavages have been welded together and the crystalline structure entirely destroyed, may crystallize anew under very many conditions,

I have recently seen a section of a steel cannon which was forgotten in the reheating furnace. When it was discovered and removed it was only a friable agglomeration of small, but well characterized, crystals. So no doubt a piece of compressed ice, maintained for a long time in a confined atmosphere—so as to prevent evaporation—and passing constantly to and fro in temperature, from 0° to —10°, would become crystalline and cleavable. I do not know if the experiment has ever been made; but it would certainly be worth the trouble.

Let me, just here, ask you to note how closely the point which Helmholtz maintained against Tyndall, relative to the innumerable crackings produced in ice by pressure, which permits the moulding of granular compressed ice into any shape, and hence allows it to flow though an opening, like a vein of liquid or like a wire, under the influence of hydraulic pressure, as Helmholtz in a recent lecture has experimentally shown; how closely the point which he makes, that the flowing of solid ice is simply the flowing of an infinite number of minute polyhedrons, resembles the theory which has been quite lately advanced by M. Tresca, concerning the laws of the flowing of solid bodies generally.

Thus far I have said nothing of fibrous iron, because the fibrous state of iron is not a normal and regular one. All crystalline iron, if the crystals are not too hard, breaks with a fibrous structure, if time be given, in the breaking, for these crystals to be drawn out into fibres. Iron which is fibrous is only iron in which the primitive crystals, surrounded by very thin films of slag—and thus separated from each other—have not been welded together during the rolling, but have been elongated into wires. A bar of such iron resembles a bundle of wires in its resistance to traction, but it breaks with a granular fracture when exposed to a transverse blow, suddenly applied.

In considering these two states of iron, the crystalline and the amorphous, we are unavoidably brought face to face with the question, what takes place when the metal passes from one of these states into the other? The experiments of MM. Favre and Silbermann, and of M. Ditte, have shown that bodies in crystallizing disengage heat; and, on the contrary, that they absorb heat in passing from the crystalline into the amorphous condition. This latter condition seems, therefore, to be an intermediate one between the crystalline state, which is a true solid form, and the state of a liquid. The amorphous state is consequently a dynamic state, as I have seen it somewhere defined; a state

of more or less unstable equilibrium. Has the crystalline iron which issues from the puddling furnace, and which we transform into amorphous iron by shingling and welding, absorbed any heat? Has it rendered latent any portion of the heat yielded by the fire or developed under the hammer? Are the specific heats of crystalline and of forged iron, at the same temperature, the same? Both these questions, interesting as they are to the theory of iron making, are yet without an answer.

Moreover, may not the heat which has thus been absorbed, being disengaged again under conditions at present but little known, become an active agent in returning the iron to its original crystalline condition, thus explaining those changes of structure hitherto attributed vaguely to great cold, to continued vibration, etc.? I have seen a bar of good charcoal iron from Franche-Comté, left accidentally for some weeks in the welding furnace, and having hence been subjected to intense heatings followed by extremely slow coolings; it had taken on a structure completely and largely crystalline, and yet had lost none of its original softness. Large forgings, such as armor plates, which have to be returned many times to the reheating furnace, and which, after each heating, cool very slowly under the repeated blows of the hammer, exhibit a strong tendency to crystallize in those central portions which are not reached by the blow. In fact these plates do often crystallize at the centre. In order to remedy this condition of things, which constitutes a serious defect, since fracture takes place readily through these cleavages, it is necessary after the plate is entirely finished, not to allow it to cool to the centre, but to place it again in the fire until the exterior has become red hot. It is then plunged into water, which for small articles must be hot, but is cold for large ones like armor plates. In this way the iron recovers its former strength. Without this precaution a plating of good soft-iron would break under the blow of a projectile, with large crystalline facets, instead of resisting its impact. This hardening of masses of iron, which is a device now extensively practiced, does not succeed unless the iron be very soft. It is necessary too that the iron should not be hard from the presence in it either of carbon or of phosphorus. The rapid cooling of amorphous iron of a good quality appears to prevent the formation of crystals; very slow cooling, on the other hand, seems to have the contrary effect.

One step more. If in place of considering water and iron in the solid state we compare them in the liquid condition, we find here,

too, many curious facts well worthy of investigation. We know, for instance, that water may be cooled, even to —12° without ceasing to retain its liquid form, if it be left in absolute quiet, and protected from the air. We also know that when in this condition vibrations of any sort, such as would be caused by drawing a bow across the edge of the vessel which contains it, or the contact of a small bit of ice, suffices to determine the solidification at once. The point at which which ice melts is therefore fixed; the point at which water solidifies is not; water may solidify at a number of temperatures. It passes into the solid state, however, when it does congeal, as much more rapidly as the temperature is inferior to the fusing point, disengaging therefore, in the process, an amount of heat proportionally greater. When the solidification takes place thus rapidly the molecules have not time to take their positions of stable equilibrium, and crystallization cannot operate. Now have these phenomena of aqueous surfusion anything analogous in the case of molten iron? Would not this be the proper place for some curious comparisons with what we observe in the casting of iron and steel? The temperature at which steel solidifies has certainly considerable influence upon its grain. We recall here, too, the practice commonly employed with certain steels, of closing hermetically at once the ingot moulds, as soon as they have received the metal, and then abandoning them to rest until the solidification is complete. We know, too, that when the steel solidifies in a mould which is in motion, the structure is more massive and less crystalline than when the mould is at rest.

I have now reached the end of my long address. You will pardon me, I trust, for having made it rather a lecture than an opening discourse upon principles and methods. Permit me, in closing, to reiterate the assertion that there are many points in the molecular states of iron which will richly repay the attention, not only of men of science, accustomed to the most delicate researches, but also of those practical men who, as engineers, are engaged in the manufacture or the utilization of this metal. I shall deem myself most fortunate if my feeble voice shall induce even a single physicist to undertake the investigation of some of the problems which suggest themselves in practice; problems, our ignorance of the solution of which prevents progress in all those directions, at least, where it is absolutely necessary to have, as a guiding thread, a sound theory built upon experience.

ON THE MECHANICAL PROPERTIES OF MATERIALS OF CONSTRUCTION,

And on Various Previously Unobserved Phenomena, Noticed during Experimental Researches with a New Testing Machine, with Autographic Registry.

By Prof. R. H. Thurston.

Section II.

SOLUTION OF PROBLEMS AND EXPERIMENTAL RESEARCHES.

14. Introductory.—The preceding section has been devoted to a description of the peculiar form of testing machine employed by the writer during these researches, to an account of the general method of obtaining from any material an autographic record of its mechanical properties, and to the interpretation of strain diagrams thus obtained from the useful metals, and other materials of construction.

The part here presented contains an account of some of the more interesting and fruitful of the special investigations conducted with the apparatus, and embodies a description of certain remarkable and hitherto unobserved phenomena accompanying the distortion of metals, the discovery of which must affect the theory of the effect of stress in producing strain, and consequently must somewhat modify engineering practice.

15. General Deductions.—From what has already been shown, we may deduce the following *résumé* of methods of determining the several more important properties of materials by an inspection of their strain diagrams.

(1). *To Determine the Homogeneousness of the Material.*—Examine the form of the initial portion of the diagram between the starting point and the sudden change of direction which has been shown to indicate the elastic limit. Notice, also, its inclination from the vertical, and compare with it the inclination of the "elasticity line."

A perfectly straight line beneath the elastic limit, perfectly parallel with the "elasticity line," shows the material to be *homogeneous as to strain; i. e.*, to be free from internal strains, such as are produced by irregular and rapid cooling, or by working too cold. Any variation from this line indicates the existence and measures the amount of strain. A line considerably curved, as in No. 6, Plate I, exhibits the existence of such strain.

Next, examine the form of the curve immediately after passing the elastic limit.

A line rising from the elastic limit regularly and smoothly, approximately parabolic in form, and concave toward the base line, as in No. 22, indicates *homogeneousness in structure*, and the absence of such imperfections as are produced in wrought iron by cinder, or in cast metals, which have been worked from ingots, by porosity of the ingot.

A line turning the corner sharply, when passing the elastic limit, and then running nearly or quite horizontal, as in other irons and in the low steel of Plates II and III, or actually becoming convex toward the base line, as with some of the woods in Plate I; and then, after a time, resuming upward movement by taking its proper parabolic path, indicates a decided want of this kind of homogeneity. The relative length of the depressed portion of the line, and the amount of depression, measures the relative defectiveness of materials compared in this respect. Finally, compare the diagrams produced by several specimens of the same kind of material, or from the same mass.

Homogeneousness in general character and *homogeneousness in composition* are proven by the precise similarity of these diagrams, while a greater or less variation of the curves compared, indicates a greater or less difference in the specimens of which they are the autographs.

Materials should usually exhibit great homogeneousness in all these three ways, to be perfectly reliable. *Perfect* homogeneousness is not to be expected in either respect.

(2). *To Determine the Elastic Resistance of the Specimen.*—Measure the height of the curve at the elastic limit, using the scale of torsion, or for tension, which is given for each machine and for each standard size of test piece, as shown in the accompanying plates.

(3). *To Determine the Resistance Offered to any Given Amount of Extension, or that Producing a Given Set.*—Measure the ordinate of the curve at the point whose abscissa, or distance from the origin, measures the assumed degree of set.

(4). *To Determine the Ultimate Resistance of the Material.*—Measure, in a similar manner, the maximum ordinate of the curve.

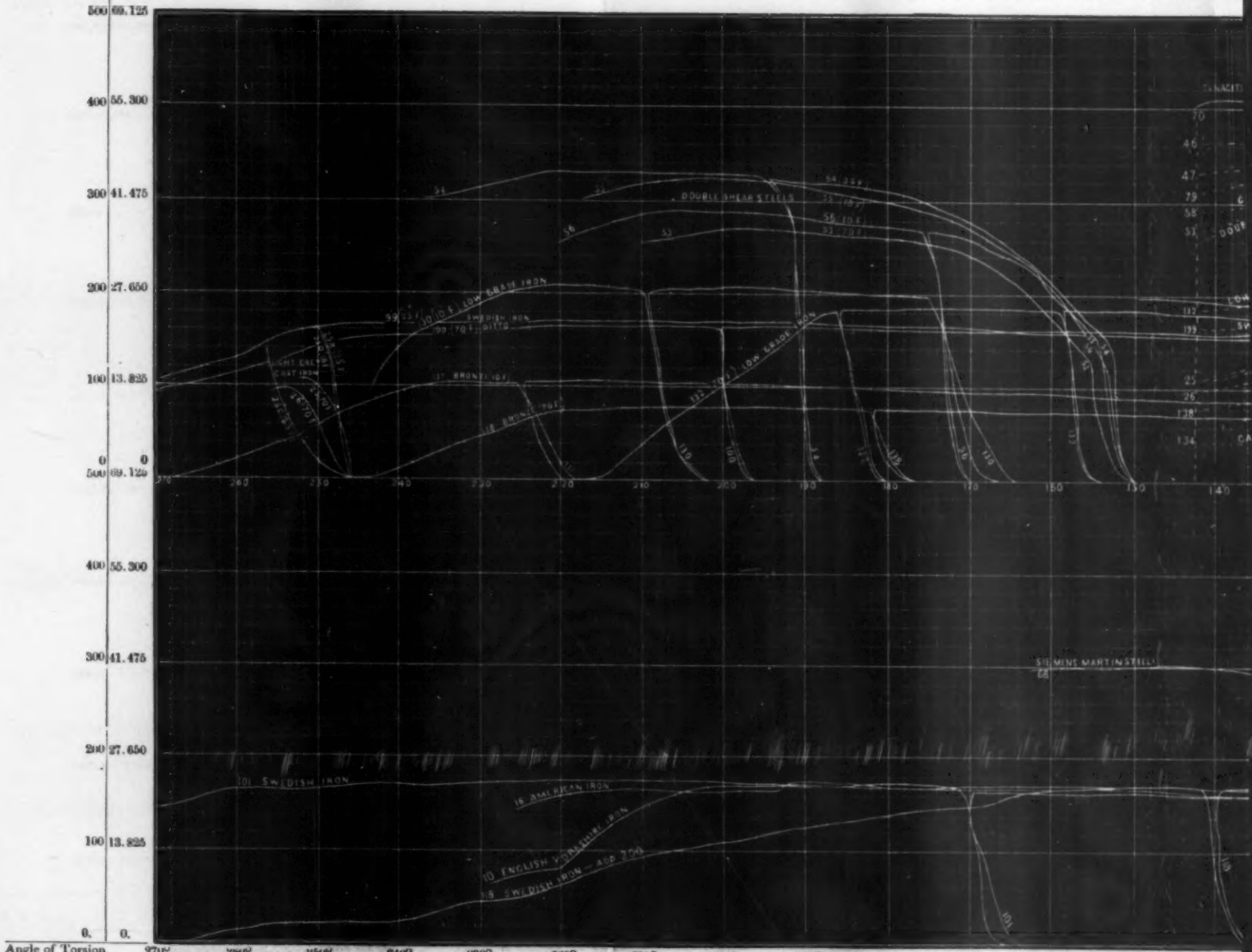
(5). *To Determine the Resilience of the Piece Within the Elastic Limit; i. e.*, the work required to produce an evident and permanent set, approximately proportional, in amount, to the degree of change of form of the specimen. This quantity measures the power of the material to resist blows, and its determination is evidently quite as important as that of resistance to static stress, which latter forms one of the factors of the former.

AUTOGRAPHIC STRAIN

ILLUSTRATING THE EFFECTS OF TIME

PRODUC

TESTING MACHINE OF PR



Angle of Torsion.	270°	260°	250°	240°	230°	220°	210°	200°	190°	180°	170°	160°	150°	140°
Elongation.	.7800	.7360	.6910	.6460	.6060	.5640	.5190	.4800	.4460	.4010	.3635	.3275	.2920	.2585

APHIC STRAIN-DIAGRAMS OF METALS,

ILLUSTRATING THE EFFECTS OF TIME AND OF TEMPERATURE UPON RUPTURE,

PRODUCED BY THE

TING MACHINE OF PROFESSOR R. H. THURSTON.

	170°	160°	150°	140°	130°	120°	110°	100°	90°	80°	70°	60°
	.3635	.3275	.2930	.2585	.2255	.1955	.1665	.1385	.1135	.0910	.0705	.0520

Approximate Tensile Resistance. Kilograms per square Millimetre.	Pounds per square Inch of Section.
105.460	150.000
84.369	120.000
63.277	90.000
42.185	60.000
21.092	30.000
0.	0.
105.460	150.000
84.369	120.000
63.277	0.000
42.185	60.000
21.092	30.000

60°	50°	40°	30°	20°	10°	0°	Angle of Torsion.
.0620	.0465	.0235	.0130	.0060	.0015	0	Maximum Extension.

Measure the area comprised between the ordinate of the curve at the elastic limit and the initial part of the curve. This quantity is proportional to the required value. *Or*, multiply the elastic resistance of the material by the extension within the elastic limit. As an approximate result, two-thirds this product is the quantity required, in inch-pounds or foot-pounds, according as measures of extension are taken in inches or feet.

(6). *To Determine the Resilience of the Material Within any Assumed Limit of Extension, i. e.*, the magnitude of blow required to produce a given set.

Measure the area of the curve up to the assumed limit; as, for example, the area, in Plate III, under No. 21, *Z*, 21, 21, *Y*, *x*; where the assumed set is the extension from *Z* to *x*. Two-thirds the product of the resistance, measured by the altitude *Y x*, and the extension δx, gives, as before, an approximate value for ordinary purposes.

(7). *To Determine the Total Resilience*, or shock-resisting power, of the material. Measure the total area of the diagram. For ductile materials, an approximate value is obtained by taking two-thirds the product of the maximum tenacity by the maximum extension. For hard and very brittle materials, one-half the same product gives very accurately its values. For intermediate qualities, the true value is more nearly two-thirds this product, also. Swedish wrought-iron, white cast-iron, and hardened steel illustrate the first and the second classes; ordinary tool steels are examples of the third class, as is also iron like No. 22.

(8). *To Determine the Effect of a Load Given in Pounds per Square Inch of Stress.*—Find a point in the curve having an ordinate which measures the given stress. The abscissa of that point measures the extension under that load. In other words, a point being found in the curve, the height of which above the base line is equal to the load per square inch, its distance from the origin measures the extension of the material as produced by that stress.

(9). *To Determine the Effect of a Blow, or a Shock, whose Measure is given in inch-pounds of Energy, i.e.*, of which the work, which it is capable of doing, is known.

Find a point on the curve whose ordinate cuts off an area, between itself and the origin, representing the given amount of work. Or, find such a point that two-thirds the product of the stress measured

by its ordinate, and the extension corresponding to its abscissa, is equal to the number of inch-pounds given. The position of this point shows the maximum strain and the maximum extension of the material under the assumed conditions.

Drawing a line through this point parallel to the nearest "elasticity line," the distance of the point at which it intersects the base line from the origin indicates the resulting set.

(10). *To Determine the Effect of a Blow upon the Material when already Strained by a Dead Load.*—Determine first the extension produced by the application of the static stress, as in (8), and then find that point on the curve between the ordinate of which and the ordinate of the point indicating the strain just found as due the dead load, an area is intercepted which measures the work done by, or the energy of, the shock which has been assumed or calculated.

16. EXAMPLES.—Illustrations of the first seven of the above described processes are given either in the preceding portions of this paper, or will be noticed hereafter during the progress of special searches. Those succeeding may be illustrated thus:

(1). Given, a load of 30,000 pounds per square inch. Determine its effect upon good qualities of cast and wrought iron, low steels, tool steel and the weaker metals.

Referring to plate II for examples, we find that neither cast copper, lead, tin, nor zinc would sustain such strain. All would be broken.

Good iron, Nos. 1 and 6, would be strained beyond their limit of elasticity and would take a set after an extension of about 1 and 1½ per cent. respectively. The exceptional iron, No. 22, would be strained to a point which is so nearly its elastic limit that it would remain practically uninjured.

The low steels, Nos. 69, 67, 76, would bear the stress with a similar degree of safety, very nearly. The first would have a considerable margin of safety within its elastic limit; 67 would be nearly, and 76 would be quite, strained to the elastic limit, while 98 would take a set of about one-fifth of one per cent.

If the strain were torsional, the weaker metals would be twisted off by a force corresponding to that here assumed, the good irons would take a set of about 25°, the best iron and the three stronger steels would take no appreciable set, and the softest of the latter would set at about 10°. In these cases, the specimens are supposed of standard

size. For other sizes the forces producing similar effects would vary as the cube of the diameters.

(2.) Given, the magnitude of a shock, or blow, *e. g.*, as equal to that due a weight of one ton,—2000 pounds,—falling one foot, the rod taking the strain being of one square inch area of section, and one foot long. Determine the effect for each of the above-named materials.

The effect of this blow is equivalent to an expenditure of energy amounting to $2000 \times 12 = 24000$ inch-pounds.

The weaker materials, not possessing an ultimate resilience of this amount, would be broken.

Forged copper would be strained, and would take a set after very nearly 12·5 per ct. of extension, since $0{\cdot}125 \times 12 \times \frac{24000 \times 2}{3} = 24000$, the work done by the blow being equilibrated by the product of two-thirds the resistance, noted at 110°, Plate II,—$\frac{24{,}000 \times 2}{3}$,—into the extension $0{\cdot}12\frac{1}{2} \times 12$ inches. Perfect accuracy of figures may be insured by perfectly accurate measurements.

The specimen of iron No. 1 would be given an extension and set of very nearly 0·068, since the resistances under this amount of stretch would be approximately 45,000 pounds per square inch, and the work during extension would be $0{\cdot}068 \times 12 \times \frac{45{,}000 \times 2}{3} = 24{,}000$ inch-pounds.

The iron of special grade No. 22 would be elongated $0{\cdot}058 = 0{\cdot}69$ inch,—as $0{\cdot}069 \times 12 \times \frac{52{,}000 \times 2}{3} = 24{,}000$ nearly.

The same blow would produce on the rod, if made of such steel as No. 69, an extension of $0{\cdot}0384 \times 12 = 0{\cdot}461$ inch, estimated thus,—$x = 24{,}000 \div \frac{2}{3} \cdot 78{,}000 = 0{\cdot}461$, it being found, by "trial and error," that the extension 0·0384 develops a maximum resistance of 78,500 pounds per square inch.

It is evident that where extreme accuracy is required the curves should be transferred to a new scale, in which the abscissas should be a scale of elongation instead of angular distortion, and the area should be carefully measured.* For the latter work an Amsler "Planimeter"† is useful.

* See London "Engineer," Nov. 8th, 1872.

† It is evident that diagrams accurately representing tests made with the common testing machine afford similar facilities for solving these problems.

(3.) Given, a bolt of dimensions as last assumed, strained with the effect of a load of 30,000 pounds, as in example (1). Determine the effect of a blow of 24,000 inch-pounds energy, occurring while the bar is sustaining the static load.

The effect of the dead load, as already calculated, is to produce a strain upon the low steels, and upon iron like No. 22, which would keep them extended only a very minute fraction of their original length, this extension being, even with the latter material, but 0·05 of one per cent.

The effect of the blow would be, practically, the same as has just been estimated for the unloaded bar.

Nos. 1 and 6 would be, as already shown, extended one and one and a half per cent., respectively, by the simple load. The added effect of the blow would be to produce an additional extension and set of 0·0533 and 0·0555 respectively, since the mean resistance, during this extension, is $\frac{45{,}000+30{,}000}{2}$ and $\frac{42{,}000+30{,}000}{2}$, respectively, and the extension must be, $24{,}000 \div \frac{45{,}000+30{,}000}{2} \div 12 = 0{\cdot}0533$, and $24{,}000 \div \frac{42{,}000+30{,}000}{2} \div 12 = 0{\cdot}0555$.

The bar is stretched, in the first case, 0·64 inch; in the second, 0·666 inch, by the blow, if made of such iron as that of specimens 1 and 6.

It should be remarked here, that although the diagrams obtained from the various materials tested give data from which to estimate their relative value in resisting shock, the absolute results of calculation, with no modification for varying rapidity of action, will be but approximate.

This is a consequence of the facts that the inertia of the body struck will affect the result, and that the actual resistance varies with the velocity of rupture. A rod which will sustain safely the blow of a heavy body, would yield readily under a blow of similar energy struck by a light weight moving with proportionally increased velocity. The mathematical investigation of this effect, which has not hitherto been noticed, remains to be given. It is only necessary to state here that a rod of uniform section, and homogeneous in structure, will be uniformly extended by a force slowly applied. A blow received at one end will extend it most at the portion nearest that end, and the more rapid the blow the more is its effect concentrated. It is possi-

ble to produce actual fracture at one end by a very rapid blow, and for rupture to become complete before the shock is felt at the opposite end. This action is seen daily in every workshop where pieces are broken from heavy masses by the blow of a hammer.

The effect of a blow depends, therefore, not only on the magnitude of that product of mass into height due its velocity which we call *vis viva*, but also upon the magnitude of the factors. It further follows that, of two materials having equal tenacity and equal ductility, that having the greatest density will be most liable to fracture by impact.* This information is confirmed by experience.

In general a rod should be somewhat larger at the end receiving the shock, and this enlargement should be greater as the blow is more rapid. Conversely, blows of equal energy are most injurious when given by bodies of light weight moving at high speed. This difference is exaggerated by any cause which increases the density of the material. The variation of resistance with rapidity of rupture will be considered more at length hereafter.

It is readily seen that we have here an explanation of the fact, that fracture produced by a quick blow is granular in character, while a steady pull brings out the "fibrous" texture of iron. In the former case the action is concentrated upon a cross-section close to the point at which the blow is received; in the latter instance inertia acts less effectively in resisting the transmission of the rupturing force to other portions of the piece, and the drawing out process is permitted to take place.

17. Peculiar Problems sometimes present themselves in practice which cannot be solved by any published methods—why, it is difficult to say, but partly, it is probable, because of a deficiency of experimental data, and partly because known authorities have not been led by actual experience in engineering practice to perceive the importance of their applications.

Of these the following is an example:

To determine the effect of a succession of stresses, whether static or dynamic, each of which strains the material beyond the original or the acquired limit of elasticity. An illustration of this action is given by the repeated bending, stretching, or other form of distortion by external force, of any material producing at each application a new set. The same case is illustrated by the gradual elongation of a rod

* "Mechanics' Magazine," Dec., 1871, p. 492.

by repeated blows, the energy of each of which exceeds the elastic resilience of the material.

Determine the elastic resilience of the material existing previous to the application of each stress, by taking the area comprised between two lines drawn through that point on the curve of the material chosen, whose abscissa represents the existing extension, one of which lines is an ordinate and the other of which is parallel to the nearest "elasticity line." This area represents the elastic resilience of the piece; *i. e.*, a blow having an equivalent energy would leave the piece uninjured and without set. Deducting this amount from the energy of the given blow, the remainder of the work done by that blow is expended in producing set or extension, and may be determined as already described.

The effect of a simple force may be determined by deducting from the total distortion produced by each application of that force, the elastic range of the material.

It is thus readily ascertained, in either case, how much each application will add to the set, and how many applications will be required to produce rupture.

It is here assumed that distortion within the elastic limit leaves the piece uninjured, however often it may be repeated. This assumption seems correct, *a priori*, and is well sustained by the valuable researches of Wohler* and others.†

The effect of repeated bending or other form of strain, can thus be inferred from an examination of the strain diagram of the material, obtaining from a single experiment a determination hitherto only obtained by a long and tedious process of repeated distortion. Such investigations of the "fatigue" of metals are often of great importance.

18. The Effect of Time on Metals left under Strain.—The effect of stress is modified when metals are left under strain for considerable intervals of time. It had generally been supposed that this effect was to weaken the resistance whenever the material was left exposed to a strain exceeding the elastic limit.

This idea seems sustained by the experiment of M. Vicat, made at Paris about forty years ago.‡

* *Zeitschrift fur Bauwesen*, 1860; *Festigheitversuche mit Eisen und Stahl*, Berlin; also Lond. *Engineering*, 1871.

† Fairbairn: *Civil Engineer and Architects' Journal*, Vols. XXIII, XXIV.

‡ *Annales de Chimie et de Physique*, 1834, Tome 54, p. 35.

M. Vicat states that four wires were extended, respectively, by $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$ and $\frac{3}{4}$ their ultimate resistance, and their elongations were observed and recorded at intervals of one year.

The relative extensions observed indicated a gradual lengthening of the three which were strained beyond the elastic limit, and that most strained finally broke, after sustaining $\frac{3}{4}$ its original ultimate breaking weight two years and nine months, the point of rupture being finally determined by the action of corrosion which had not been entirely prevented.

The several extensions were as follows:

No. 1,	sustaining $\frac{1}{4}$,	33 months,	0·000	per cent.
No. 2,	" $\frac{1}{3}$,	" "	0·275	"
No. 3,	" $\frac{1}{2}$,	" "	0·409	"
No. 4,	" $\frac{3}{4}$,	" "	0·613	"

The rate of extension was nearly proportional to the times, and the total extension to the forces. M. Vicat concludes that metal thus overstrained will ultimately break, and his paper has caused much uneasiness among members of the profession, as indicating a possibility of the ultimate failure of structures having originally an ample factor of safety.

The elegant and valuable researches, also, of H. Tresca, on the flow of solids,* and the illustrations of this action almost daily noticed by every engineer, seem to lend conformation to the supposition of Vicat.

The experimental researches of Prof. Joseph Henry, on the viscosity of materials, and which proved the possibility of the coexistence of strong cohesive forces with great fluidity,† long ago proved, also, the possibility of a behavior in solids, under the action of great force, analogous to that noted in more fluid substances.

On the other hand, the researches of the writer, as described in the first section of this paper, indicating, by the form of strain diagrams, that the progress of this flow was accompanied by increasing resistance, and the corroboratory evidence furnished by all carefully made experiments on tensile resistance, as those of King and Rodman, Kirkaldy and Styffe, made it appear extremely doubtful whether materials were really weakened by a continuance of any stress, not originally capable of producing incipient rupture.

* *Sur l'Ecoulement des corps solides*, Paris, 1869–72.

† *Proc. Am. Phil. Society*, 1844.

18. To determine this point, a series of experiments was made, the general result of which was first formally announced in a note to the American Society of Civil Engineers,† in which the first experiment, commenced during the session of the National Academy of Science at the Stevens Institute of Technology, was described, and in which the first deductions, since slightly modified by an extended investigation, were given. In Plate III, No. 16, is a *fac simile* of the strain diagram obtained at the first experiment.

A piece of iron, of a good quality of metal, but badly worked, as shown in the sketch already given in Section 1, was placed in the machine and strained considerably beyond its elastic limit. It was then left twenty-four hours under the strain thus produced at A, Plate III. At the end of this period, the pencil was found precisely as it was left, and not the slightest evidence of yielding was noted. The slight depression observed in many examples to be given, is produced by a slight compression of the wood used in blocking the machine at the beginning of the interval. No evidence of flow was therefore obtained.

Upon attempting to produce further change of form, however, the unexpected discovery was made that the test-piece had acquired an increased resisting power. The pencil, instead of following the general direction taken the day previous, rose, as seen in the diagram, until a resistance was indicated, *exceeding by nearly thirty per cent.* that shown before the specimen was left under strain. This resistance having been overcome, the piece yielded with a slightly decreasing resistance, and, after considerable additional distortion, was left at B twenty-four hours. The result of the second experiment is seen to be an increase of nearly fifteen per cent., and a third trial at C gave a small, but still perceptible, gain also.

This singular phenomenon appeared so remarkable and so important that experiments were continued upon various grades of iron, and upon other metals, the greatest care being taken to avoid any possible source of error. Several strain diagrams are given illustrating some of these experiments.

No. 10 represents that of a piece of good iron which is far more homogeneous and better worked than 16.

No. 68 is a piece of "Siemens-Martin steel" which was left under

† *See Trans. Am. Soc. C. E.*, Nov. 1873; *Journal Franklin Institute*, March, 1874.

strain, at *A*, twenty-four hours, and at *B* an equal length of time. In the latter case, the applied force was wholly removed, at the end of twenty-four hours, before an attempt was made to produce further change of form. On renewing the strain the resistance is seen to have acquired an increased intensity very nearly absolutely equal to that shown at *A*, and relatively greater, a fact which will be found to aid in the determination of the real character of the phenomenon. A third experiment, at *C*, shows a repetition of this action, and a fourth, similar to that at *B*, in all except time—for in the last experiment the time was but a fraction of an hour—gave a similar result. In each case it is noticeable that a slight fall from the maximum attained follows the yielding of the test-piece.

No. 33, malleable cast iron, No. 52, double shear steel, and No. 81, tool steel, all exhibit this same stiffening under prolonged strain.

No. 17, "homogeneous chrome iron," was subjected to experiment four times. At *A*, the effect is very marked, and the resistance to further change of shape continues to increase slowly until left at *B* for a second trial. The maximum attained at *B* is not sustained, as further distortion occurs, and, after a slight decrease, the specimen was again left, the pencil resting at *C*.

Next day, the increase of resistance was found less considerable than at the previous experiment, and the line, after passing a maximum a few degrees beyond, falls quite rapidly. Fearing that the metal was about to rupture completely, it was left once more at *D*, another day, after which time its behavior was similar to that on earlier trials. It fully regains the maximum power of resistance noted after the trial at *C*, and, before rupture, it even slightly exceeds it.

The hardest material experimented upon was the very hard chrome steel, No. 21. Left at *A* three days, the resistance at that degree of distortion was increased about eight per cent., and, again at *B*, four days under strain gave a rise of nearly four per cent., after which a considerable rise occurred, in the ordinary manner, before rupture took place.

An interesting experiment was made with the best Swedish iron, a metal of such wonderful purity and ductility that one specimen, of standard size. was twisted nearly 600° before completely breaking off.

No. 101, Plate III, is the strain diagram of the specimen tested for the purpose of determining the effect of continued stress. Here,

as seems frequently the case, a loss of ductility apparently accompanies the increase of resistance. and the total resilience appears to be comparatively slightly altered.

This specimen was strained until the limit of elasticity was just passed and was then left at *A* one day. The result, with even this slight distortion of but six degrees, producing an extension of a very minute amount, is similar to that before noticed, and the behavior here exhibited probably gives a clue to the causes of this peculiar action. After this trial several others were made, and the metal is seen to have behaved in a manner precisely similar to the other grades of iron.

20. Reviewing all of the large number of experiments made since the discovery of this effect of continued strain, carefully comparing the curves obtained with each other, and with the diagrams obtained in the ordinary way, and, finally, making a comparison of the conclusions drawn from this research, with the results of the experimental work of other investigators, the writer has been led to the following, as the most probable explanation of this singular molecular phenomenon.

These strain diagrams are the *loci* of the successive limits of elasticity of metal, at successive positions of set.

The phenomenon here discovered is an elevation of the limit of elasticity by a continued strain. The cause is probably a gradual release of internal strain, occurring in a somewhat similar manner to that observed previously in cast iron in large masses, and, less frequently, and generally in a less marked degree, in wrought iron and other metals, which have been worked in large pieces, and in which such strain has been more or less reduced by a period of rest.*

This loss of strength in large masses of wrought iron is stated, by Mallet, to amount frequently to one-half.†

* Compare London "Iron," Stability of Iron Structures, Feb., 1874; Van Nostrand's Magazine, April, 1874.

† On the co-efficients of elasticity and rupture in wrought iron in relation to the volume of the mass, its metallurgic treatment and the axial direction of the constituent crystals. *Proc. Inst., C. E.*

(To be continued.)

SECOND CHEMICAL AND SANITARY REPORT UPON THE WATER SUPPLY OF THE CITIES OF NEWARK AND JERSEY CITY.

By Professor Henry Wurtz.

(Corrected and prepared for this Journal by the Author.)

(Continued from page 337.)

2. *The River at the Falls.*—The sample collected July 24, above the falls (No. 9), will do well to compare with the series collected on the previous day in the lower basin. In appearance it was beautifully limpid, this limpidity being due to the long, still, deep and shady two-mile reach just above the falls, which acts as a settling reservoir. I may here throw in the suggestion that the canal—were it to be taken by your Honorable Commission as an aqueduct, and the continual wash against the banks, from the boats, thus ended—would do a like work with this extended lagoon above the falls, and its water would quickly become equally limpid and translucent. On proceeding up-stream towards Little Falls—as soon as the lagoon was passed and the water began to ripple (which is somewhere about the Midland Railway Viaduct), it was seen to be opalescent, so that the bottom could scarce be discerned at one foot depth; the impurities from the factories and dwellings at and about Little Falls becoming perceptible to the eye, as well as to the smell and taste.

The analyses quoted in Table III furnish an idea of the changes impressed on the water by passing through the cities of Paterson, Passaic, etc. We may compare for this purpose the mean of the two low-tide samples, Nos. 2 and 4, as well as some of the figures of No. 2 directly.

It appears, therefore, that the Belleville water averages a grain more per gallon of total solids, and about a grain and a quarter more of mineral matter, derived from town sewage, than that above the falls, but that the silt precipitated by the sewage below the falls, or some other agency, makes away with 0.36 grain of the organic matter present. The nitrates are less at Belleville, through action of vegetation in the stream below the falls. The "albumenoids," however, notwithstanding the constant absorption by weeds and fish, are more than doubled, and if we take the result in the low-tide water alone, at the Newark Works, nearly quadrupled. The chlorine also undergoes a marked increase, as it inevitably must from sewage contamination, from 0·252 to 0·332 in the low-tide Newark water.

TABLE III.

Numbers.	SAMPLES.	Total Solids.	Loss on incineration	Ash.	Nitric Acid.	Saltpetre equivalent	Ammonia from Animal matter.	"Albumenoid" matters.	Chlorine.	Common Salt equivalent.
9	Passaic River, at head of Falls	4·584	1.501	3·083	0·334	0·624	0·023	0·234	0·252	0·416
2 & 4	Mean of two Low-tide samples at Belleville	5·431	1.140	4·291	0·303	0·567	0.049	0·496	0.274	0·452
2	Low-tide sample at Newark Works	.....	.....	.....	0.233	0·433	0.087	0·875	0·332	0·547

TABLE IV.

Illustrating the successive changes of composition of Passaic Water, while flowing from the Falls at Paterson to and through Newark, and back again to Belleville with the rising tide—during the Summer season.

Number.	[1] SAMPLES.	[2] Total solids.	[3] Loss on incineration.	[4] Ash.	[5] Nitric Acid.	[6] Saltpetre, equivalent to the Nitric Acid.	[7] Combined Ammonia.	[8] Urea, equivalent to the combined Ammonia.	[9] Ammonia from Animal matter	[10] "Albumenoids."	[11] Chlorine.	[12] Common Salt equivalent to the Chlorine.
9	Water of Passaic Falls—July 24	4.584	1·501	3·083	0·334	0·624	.....	.....	0·023	0·234	0.252	0.416
2	Low tide at Newark Water Works—July 23	5·455	1·105	4·350	0·233	0·433	0·023	0.041	0·087	0·875	0·332	0·547
4	" " Jersey City Water Works—July 23	5·407	1·175	4·232	0·374	0·700	none	none	0·012	0·117	0·216	0·356
16	River in Newark—just before ebb—August 20	5·249	1·575	3·674	0·187	0·350	0·058	0·103	0·117	1·167	.....	.....
17	" " " just after flow began—August 20	5·833	1·458	4·375	0·037	0·070	0·929	0·052	0·292	2·916	.....	.....
3	High tide at Jersey City Water Works—July 23	6·178	0·772	5·456	0·374	0·700	none	none	0·029	0·292	0·288	0·476
1	" " Newark " " "	5·995	0·647	5·348	0·278	0·520	0·012	0·021	none	none	0·433	0·713

Nevertheless, it must be frankly said that this analysis of the water of the falls at Paterson by no means justifies the high estimate that the people of that pleasant city appear to entertain of the purity of their water supply; but rather agrees with what might be expected of a stream, one of whose tributaries (the "main" Passaic) comes down from a thickly populated agricultural country, full of towns and villages; and runs, moreover, through a large swampy district, (the "Great Piece Meadows"), frequently inundated.

On the occasion of an excursion of Chief Engineer Bailey and myself, up to Beavertown, we inspected and examined the Passaic above Little Falls. To both Mr. Bailey and myself the water in the reach above Little Falls had an unpleasant taste, and the wind blowing over it wafted a disagreeable odor. The water was not very clear in this reach. This was July 24.

In order to follow out the successive changes of the composition of the stream in its course through the lower basin, from the falls through Paterson and Passaic, through Newark, and back with the rising tide through Newark again up to Belleville, I have constructed the following table (Table IV), which, however, it must be remembered, does not furnish a strict comparison, as the samples in the city of Newark were taken nearly a month later in the Summer than the others. This table, however, will repay attentive study.

A gradual increase appears in total solids and in dissolved mineral matter, in consequence of influx of sewage. The rising tide shows less of nearly every ingredient at the Newark works than at the Jersey City works below, doubtless in consequence of greater admixture with the down-flowing water of the stream itself. This does not hold as to chlorine, however, which is increased in proportion by this admixture with the water from above, conveying the excreta of the large population of men and animals on the banks.

The nitrates are very variable, in consequence, as already explained, of variable action of vegetation in different parts of the stream, combined with the constant development of these nitrates by oxidation. There is a large increase of dissolved animal matter from the falls to the Newark Works, which doubtless contributes to support the fish that densely populate the stream at and above Belleville, and which, therefore, dwindles down rapidly, until enormously reinforced at Newark, and then again dwindles down to nothing—partly consumed by the fish, but also by vegetation and oxidation—during the up-flow. The effect of oxidation is manifest, during this

up-flow, by examining the nitric acid (column 5), which shows a maximum in the up-tide at the Jersey City works, and then a rapid diminution again, through vegetative action. Examination also of column 3 illustrates the same surprising changes—the amount of volatile and combustible matter, notwithstanding the Paterson and other sewage, actually diminishing from the falls down to the Water-works, and the maximum of these ingredients—in the channel at Newark just before ebb, 1·575 grains—running down rapidly during the flow up to the Newark Water Works to only 0·647 grain. The rapidity of these variations is here most astonishingly exhibited, and I would throw out the suggestion (or rather, on my own part, the conviction) that we owe our health (such as we have) and probably our lives, during the Summer season at least, to the concurrent action of these three causes, animal and vegetable life, and oxidation. Should any one, and especially any two, of these fail us, the consequences may readily be conjectured. At some time, as may be confidently predicted both the plants and fish will fail us. The very excess of nourishment that we now provide for these living things may at any time lead to their sudden or rapid extinction, as, in fact, it already has at other points in the river.

3. *The Canal—The Long Level.*—On the same occasion referred to above, of the excursion with Mr. Bailey, the water of the canal was examined and tested at several points. It was found to be more or less turbid, from the constant wash of the banks. The taste of the water opposite Little Falls appeared to be of an earthy or clayey character, very slight, and probably due to the same cause as the turbidity. This taste I was unable to perceive at the point near Beavertown, where our sample was collected, which is, I should add, on the same level (the "seventeen-mile level").

It will be observed that the results of the analysis of this sample compare much to its advantage with that of the Passaic Falls, there being a trifle more of mineral matter, however, which is no important objection. (See Table V.)

This, moreover, does not tell the whole story, for the canal, after taking in below, upon this same level, the water of the Pompton feeder, which is much purer still, must change its composition very considerably for the better.

In the next paragraph this will be again referred to.

TABLE V.

SAMPLES.	Total Solids.	Loss on Incineration.	Ash.	Nitric Acid.	Saltpetre.	Combined Ammonia.	Urea equivalent.	Ammonia of Animal origin.	"Albumenoid" matters.	Chlorine.	Common Salt.
Water of Passaic Falls	4.584	1.501	3.083	0.334	0.624	undet'd	undet'd	0.023	0.234	0.252	0.416
Morris Canal, above Pompton Feeder	4.231	0.881	3.350	0.186	0.347	none	none	none	none	0.144	0.238

TABLE VI.

SAMPLES.	Total Solids.	Loss on Incineration.	Ash.	Nitric Acid.	Saltpetre equivalent.	Combined Ammonia.	Urea equivalent.	Ammonia of Animal origin.	"Albumenoid" matters.	Chlorine.	Common Salt equivalent.
Water of Pompton Plains Feeder	3.332	0.764	2.568	0.139	0.260	0.003	0.005	0.029	0.292	0.115	0.190
Calculated Composition of Long Level, below Feeder	3.781	0.822	2.959	0.162	0.303	0.001	0.002	0.014	0.146	0.129	0.214
Water of Reach, above Falls	4.584	1.501	3.083	0.334	0.624	.....	.....	0.023	0.234	0.252	0.416

4. *The Pompton Plains Feeder.*—As this feeder may be made to bring down the whole of the waters of the Pequannock, the Ramapo, the Wynockie, and the Ringwood, including the water of Greenwood Lake—comprising certainly more than one-third of the whole Passaic water-shed, while coming from a country far less populated and cultivated than the Croton shed—it appeared to me of the utmost importance to examine it well. It will be seen that the results of the analysis fully sustained the expectations formed. Table VI, gives these results by themselves, together with a calculation of the composition of the water of the long level above Patterson, which extends to Bloomfield, on the supposition that the main canal and this feeder bring down equal quantities of water.* I repeat again, for comparison, the composition of the falls:

It would certainly be possible to supply all the low-lying business parts of your two cities (which consume all but a small fraction of the water-supply), through the long level, from this feeder alone, for an almost indefinite time to come, with what is clearly one of the purest waters in the United States. I am here, however, probably intruding somewhat on the engineering questions, which do not lie within my province.

Whether this feeder, or the main canal or any part thereof, be made use of to obtain the proposed water-supply, I have to point out that there are many places along both where the embankments are not continuous, and where small portions of the adjacent land are overflowed, and where shallow pools are accordingly formed, necessarily more or less stagnant, and full of growing and decaying vegetable matter. Such should all be carefully diked off by well puddled embankments.

To be continued.

*It is, nevertheless, proper to add that the amount of the purer water *obtainable* through the feeder is greatly in excess of that which the main canal can bring; probably, indeed, nearly three times as great, so that a far larger allowance than the above may justly be made, on the side of purity, for the mixture·

APPENDIX.

Franklin Institute Exhibition, 1874.

RULES AND REGULATIONS.

1. The building on Market Street between Thirteenth and Juniper Streets will be open for the reception of all articles and goods intended for exhibition, on Monday, September 14th, and remain open for that purpose until Saturday, October 3d. On Tuesday, October 6th, the Exhibition will be formally opened to the public at 12 o'clock, M., and continue daily open (Sunday excepted) from 10 A. M. to 10 P. M., until Saturday, October 31st.

2. Each Exhibitor will be required to pay Five dollars for each and every entry for competition, at the time the entry is made, and no more than one premium shall be awarded for articles contained in same entry; a *season ticket* shall be furnished to each such exhibitor, *which shall not be transferable*. Not more than one exhibitor's ticket shall be furnished to any one firm or corporation for each entry. Exhibitors may procure tickets for persons necessary for the care and operation of their articles, free of charge, but to be forfeited if used improperly. Articles intended for display only, may, at the discretion of the Committee, be entered without fee; but such entry will confer no privileges upon the exhibitor.

3. All applications for space to be made before October 3d, on printed blank forms, to be furnished by the Committee; and they will be considered and the space allotted in the order of their receipt. Space allotted to applicants and not occupied by October 3d, may be assigned to other exhibitors. Whenever the articles will admit, contributors are requested to exhibit them in glass cases.

4. All articles delivered at the building shall be reported to the Committee, who will direct their location, and assign them the proper space. Any articles shipped to the Exhibition by rail or otherwise, must have freight and charges pre-paid, and invoice and bill of lading mailed to "Committee on Exhibition."

5. Exhibitors will be furnished by the Entry Clerk with duplicate cards, describing each article entered for exhibition; these will be countersigned on the receipt of the articles into the Exhibition. One of these cards shall be conspicuously attached to the article which it describes, and the other must be retained by the exhibitor, and be presented as his order for the delivery of the articles specified, at the close of the Exhibition.

6. The Committee reserves the right to exclude from the premises all articles of a dangerous or offensive character.

7. No articles can be removed from the building, during the time of Exhibition, unless by consent of the Committee.

8. A police force will be in attendance upon the premises during the Exhibition, and watchmen at night; but all articles on exhibition will be at the risk of the owner.

9. There will be two lines of shafting of two and seven-sixteenths inches diameter, one line driven at a speed of 120, and one at 240 revolutions per minute, from which power will be furnished, without charge, for machinery in operation. To secure entire uniformity of motion, all driving pulleys on the line shaft will be supplied by the Institute to the exhibitors, at the lowest trade price. Exhibitors will furnish their own counter-shafting and belting, all plainly marked with their names.

10. The Judges shall be appointed by the Board of Managers, and shall be men

of acknowledged integrity, skill, and experience in the class of articles assigned to them; and no Judge shall serve on any class, in which he may be a competing exhibitor, or otherwise directly interested. The mornings of each day, until fifteen minutes before the time of opening the Exhibition, shall be appropriated to the Judges, who shall be attended only by such persons as they may invite to be present.

11. All articles entered for competition will be carefully examined by the Judges, and Premiums will be awarded on such articles as they shall declare worthy—their decisions being based on intrinsic merit, and not because the article happens to be the best exhibited in any particular class.

12. The Premiums to be awarded shall be of three classes:

1st. The Silver Medal of the Franklin Institute, with a Diploma or Certificate setting forth the peculiar merits of the article exhibited.

2d. The Bronze Medal of the Franklin Institute with a like Diploma.

3d. A Diploma or Certificate of Honorable Mention.

Cases of special merit may be referred by the Judges to the Committee on "Science and the Arts," with a recommendation for the award of the Scott's Legacy Premium, or of the Elliott Cresson Gold Medal.—(See opposite page.)

13. Exhibitors are desired to state in writing to the Committee the peculiar merits claimed for the articles exhibited by them for competition.

14. Signs will not be allowed of greater size than 300 square inches, nor shall such signs be elevated above the goods.

The distribution of circulars and cards or samples about the building will not be permitted; exhibitors can distribute only from their own stand.

Address of the Board of Managers.

To Manufacturers and Mechanics of the United States:

In inviting Contributions to an Exhibition which is intended to celebrate the 50th year of the Franklin Institute, the managers naturally recall the language used by the founders of the Society in their first quarterly report, made to the Institute upon the 15th of April, 1824.

Announcing the intention of holding the first Exhibition of the kind in this country (which was actually held in the month of October, in the year 1824) they say:

"An object of equal, if not greater importance * * * * * is that of public "Exhibitions to which all the products of national industry may be sent; the effect "and consequence of such Exhibitions will necessarily be to extend the reputation "of the Institute, to stimulate the zeal of the members, and to excite a proper "degree of emulation and of justifiable rivalry among the numberless manufacturers "and mechanics of this city. It is confidently believed that when the products of "our industry are collected from the various workshops now dispersed throughout "the city and state, and exhibited together, they will form a collection calculated "to excite a gratifying sense of pride in the bosom of every well-wisher to the "prosperity of our manufactures, and an encouraging hope that, under proper regu-"lations, we may soon compete with foreigners in the manufacture of all useful "articles."

These views and hopes have been justified by the success of their pioneer enterprise and of those which followed it, as well as by the general practice now existing, of Annual Exhibitions elsewhere, but more than all, by a comparison of the state of the Arts, fifty years ago, with their condition now.

This comparison may, we trust, be facilitated and illustrated by our intended Exhibition. It cannot be denied that much of the general progress of the Mechanic Arts may fairly be attributed to such expositions, and prosperity in many individual

cases may easily be traced to the public recognition which our exhibitions have invited. On the other hand, the benefits to the community have been equally great, and all the motives which were enumerated by our first Board of Managers are fully in operation to-day.

We hope, therefore, when self-interest and the desire for the public good both incite us to one line of action, that the parties to whom we especially appeal may unite to make our proposed display worthy of the occasion.

In the earlier Exhibitions held by the Franklin Institute, a list of premiums offered was published beforehand, but experience proved that many of the Medals were neither earned or awarded, while the acknowledged excellence or novelty of other articles exhibited, compelled the award of Medals which had not been proposed The plan was therefore definitely abandoned in 1838, and Medals may now be achieved for any product of Inventive Genius, or by excellence of Execution.

The Scott Legacy Premium, consisting of a Bronze Medal, with the motto "To the most deserving," together with the sum of $20, is vested in the City of Philadelphia by the provisions of the Will of John Scott of Edinburgh, made in the year 1816, and the city has confided the trust of awarding the premium to the Franklin Institute. It is a premium of peculiar honor, to be distributed among ingenious men and women who make useful inventions.

The Elliott Cresson Gold Medal, an honor which has rarely been awarded, is also entrusted, by the provision of his Will, to the Franklin Institute. It may be awarded for some discovery in the Arts and Sciences, or for the invention or improvement of some useful machine, or for some new process or combination of materials in manufactures, or for ingenuity, skill or perfection in workmanship.

Both of these premiums are awarded by the Board of Managers upon the recommendation of the Committee of Science and the Arts.

In order more readily to find experts qualified to act as judges of each class of articles exhibited for competition, the classification will be made according to the position each article occupies in trade, without regard to any rule based upon the use of the article.

The Rules and Regulations, adopted by the Board of Managers to govern the Exhibition, and all other necessary information, are given herewith.

By order of the Board of Managers,

D. SHEPHERD HOLMAN, *Actuary*.

PHILADELPHIA, *May 13th*, 1874.

INFORMATION.

THE EXHIBITION BUILDING.

The Pennsylvania Railroad Company being about to vacate their Depot on Market Street, between Thirteenth and Juniper Streets, has, with characteristic liberality, placed the building at the disposal of the Committee on Exhibition.

This building contains more than two acres of available space on the ground-floor, besides a large cellar for Storage, and a four story wing at the corner of Thirteenth Street, for Offices, and is therefore by far the largest Exhibition building ever had in Philadelphia.

TRANSPORTATION.

The following Railroad and Steamship Companies have agreed to return free, *over their own lines*, articles which they have carried, intended for the Exhibition, upon which freight has been paid, and which remain unsold.

The paid Freight-bill, countersigned by the proper officer of the Institute, will entitle exhibitors to this privilege.

Pennsylvania Railroad Company.
Philadelphia, Wilmington and Baltimore Railroad Company.
Philadelphia and Reading Railroad Company.
North Pennsylvania "
Lehigh Valley "
Phila. and Baltimore Central "
West Chester and Philad'a "
West Jersey "
Camden and Atlantic "
Clyde's Steam Lines—To Boston, Providence, New York, Richmond, Norfolk, Charleston and Washington.
Philadelphia and Southern Mail Steamship Co.
Baltimore and Philadelphia Steamboat Co.
Swiftsure Transportation Co.—To New York and Hartford.
Boston and Philadephia Steamship Line.
Philadelphia and Providence Steamship Line.
Lorillards' New York Steamship Line.

The last three Steamship Lines will make a charge for the handling of heavy machinery on the return.

INSURANCE.

Parties desiring to insure against Loss by Fire during this Exhibition, may do so upon a general policy issued to the Franklin Institute, by recording the amount and paying the premium.

SPECIAL TRIALS OF ENGINES AND BOILERS.

In addition to the examination of Stationary Steam Engines and Boilers under the regular rules, covering *all* the qualities comprised in the best machines, it is proposed to make a *special* trial of the evaporative power of Steam Boilers, and of the economy of Boilers with Engines attached, known to the trade as Portable Engines.

These trials to be conducted by practical and scientific experts, with Indicator and Dynamometer and other approved apparatus.

The arrangements for the trials are not yet complete and will mainly depend on the number of the machines that can be brought into competition.

All persons interested in such trials are requested to communicate with the Committee, who will furnish full information as soon as the conditions are arranged.

All communications are to be addressed to the

COMMITTEE ON EXHIBITION,
FRANKLIN INSTITUTE,
Philadelphia.